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ART. I.—*On the Suspension and Sedimentation of Clays;* by WM. H. BREWER.

IN a paper read before the National Academy of Sciences in 1883, and since published,* I have considered some of the general phenomena of sedimentation and given a partial account of experiments pertaining to the subject. Clays and the materials suspended from soils and from pulverized rocks formed part of the substances experimented on and discussed.

The continuation of the experiments then in progress confirms and extends the conclusions there stated, and this article with a succeeding one may be considered as a review and continuation of the previous paper, so far as it specially relates to the transportation of mud in natural waters and the formation of bars and deltas. In this paper I will consider the behavior of clays toward water, as shown by laboratory experiments, and in the next, the application of the same in explanation of the natural phenomena.

Erosion by running water, the transportation of suspended mud, its deposition, the formation of bars in rivers or at their mouths, the growth of deltas, the distribution of silt in lakes and harbors and on the floor of the ocean have mostly been discussed from the mechanical side only. The chemical aspects of the phenomena have usually either been but lightly considered or entirely ignored.

* "On the Subsidence of Particles in Liquids;" Memoirs of the Nat. Acad. Sci., vol. ii.

The transportation and deposition of gravels and coarse sands are probably in accordance with well-known hydraulic laws, in which the velocity of the current, the specific gravity, and the relative weight and surface of the transported materials are the only factors that need be considered in any practical discussion. But with those finer particles of disintegrated rocks which are ultra-microscopic in size and all those which though still coarser are small enough to be subject to those movements in liquids known as the "Brownian motions," and with the true clays I consider that chemical conditions rather than mere motion of the water are the controlling factors.

I have carried on a long series of experiments on the sedimentation of clays, and the finer portions of soils and pulverized rocks, mostly in tall precipitating flasks in which the materials were first agitated with the respective liquids and were then allowed to stand at rest under various conditions as to light, temperature, etc.

There is considerable difference as to details in the behavior of various clays in water. With some of them, if agitated and thoroughly diffused through the liquid and then allowed to stand at rest, the turbidity fades gradually and regularly in density from the bottom to the top, and the liquid gradually grows clearer until it becomes as clear as natural waters ever do. Usually however, and with the great majority of clays (if the water be pure enough), the deposition is in quite a different manner. After some time, it may be in a few hours or it may be only after some days, the suspended material disposes itself in layers or strata which are more or less obvious because of the different degrees of turbidity of the liquid. There may be but two or three of these layers to be seen at once or there may be six or eight, the number depending in part on the composition and fineness of the material under experiment, in part on the freedom of the water from other dissolved material than the clay itself, and in part on the temperature. Some of these layers may be and usually are very obvious, others obscure and only to be seen in the best light; some are very sharply defined, others remain ragged and ill defined along the line of separation. Some which may be obscure at one temperature become sharp and well-defined if the temperature be slowly raised or lowered a few degrees, or well-defined strata at one temperature become first hazy and then disappear at a higher or lower temperature. Sometimes, with a change of temperature, what was before one uniform stratum will slowly resolve itself into several obvious strata, which remain distinct so long as the temperature is right, but which disappear again and become homogeneous at another temperature. Thus, some suspended clays may be induced to exhibit a much larger number

of these liquid strata in the aggregate than are visible at any one time.

These different strata, having unlike degrees of opacity, settle with very different degrees of rapidity, and if the temperature be kept nearly constant and the vessel entirely at rest, their number grows less and less from the more rapid settling of the lower and heavier. The lighter ones usually settle with extreme slowness often but a millimeter per day, some even less than half that, and consequently, any cause, such as varying temperature, which sets up even very feeble currents, may so retard the ultimate clearing as to indefinitely prevent it.

If the vessel be kept in the quiet and with as nearly constant temperature as is possible, the liquid finally becomes uniformly opalescent throughout. This opalescence gradually fades for a time, from the subsidence of some of the suspended matter, and if the water contains a sufficient amount (which may be a very minute proportion) of certain salts in solution, it becomes practically clear, that is, clear to the unaided eye in ordinary daylight,—as clear as the clearest natural waters. If, however, the water be free from dissolved substances (other than the clay itself) the fading of the opalescence ceases after some time, it may be in a few weeks or it may be only after two or three years, and after that the liquid becomes no clearer by standing. The degree of opalescence may and often does vary with varying temperature, as if some of the sediment were again picked up, or as if a portion which had fallen and remained as a mobile liquid stratum on the bottom at one temperature were again raised by diffusion at another temperature. Certain very ferruginous clays under experiment, the later suspensions from which are amber-colored, change thus very decidedly and obviously from summer to winter in a vessel which is kept in the temperature of my study. In pure water the subsidence is probably never complete. Some specimens under experiment, which have stood more than seven years and which are still obviously opalescent, have not become sensibly clearer for the last four years. The last portion of this time they have rested on a shelf fastened to a heavy wall in a deep cellar and further enclosed in a closet, in which changes of temperature are very slow, and jars or motion practically none.

In the presence of mineral acids and various salts (and numerous substances not classed as salts or acids), the behavior of suspended clays is very different. If a small quantity of mineral acid, or some saline substance be added to muddy water, the strata described are either not formed at all, or are fewer and settle more quickly. If the quantity of dissolved material is sufficient, the clay curdles or flocculates and immediately falls to the bottom. If now the clear saline (or acid)

liquid be decanted from the sediment, an equal quantity of distilled water be added and the mud again diffused by agitation, the clay again allowed to settle, the liquid again decanted when clear, and this process repeated over and over, the saltness (or acidity as the case may be) of the liquid growing less with each dilution, we may study the behavior of the same portion of clay in solutions of different (and known) degrees of strength, and by repetition with the same clay in the same vessel, over a sufficiently long period of time, we may imitate the conditions which take place in the erosion and transportation of muds by rivers and their ultimate deposit in the sea.

From such experiments we may say in a general way, that the more saline the suspending water, the more rapid the sedimentation, but the rapidity of preciptation is not directly proportionate to the quantity of salts dissolved. Reducing the saltness one-half does not double the time of precipitation, and the precipitation is comparatively rapid until the solution is very weak indeed. With some clays the precipitation is as complete in thirty minutes in sea water as in thirty months in distilled water. This completeness of precipitation refers to the actual clearing of the liquid, and not the rate of deposition of the first and heavier portions.

The experiments are more striking if conducted with acids, they acting with greater intensity than salts. The successive phenomena are similar in character, and differ only in degree, the later changes are more rapid and the final suspension is more striking. For example, if we begin with a strong solution of sulphuric, nitric and chlorhydric acids mixed, and follow through repeated dilutions as above described, the flocculation and precipitation of the suspended material is almost equally rapid for several successive dilutions, and the layers or strata only appear in the suspensions when the proportion of free acid becomes minute, and with this the precipitation becomes very much slower. Finally (and this point is reached somewhat suddenly) the behavior is as in distilled water. Many strata are formed of the suspended matter, the settling of all of them is very much slower and complete clearing of the liquid is indefinitely postponed. In fact, this stratification and long suspension of clays is best seen in specimens that have thus undergone treatment with acids or salts, and then washed with distilled water through successive dilutions.

The behavior of these finer suspensions is analogous to that of a colloid. The diffusion through water is like that of a colloid, and when the finer portions are evaporated slowly and at low temperatures, they are at first very bulky and colloidal in appearance, shrinking enormously on drying into a mass curiously like some organic colloids. If the clay is not strictly

colloidal, it is indeed very like it, and its behavior toward water very similar.

The continuation of the experiments since, the preparation of the paper cited, confirms the conclusions there suggested, viz: that clays probably exist as a series of hydrous silicates, feebly holding different proportions of water in combination and having different properties, so far as their behavior to water is concerned. That some of them swell up in water (much as boiled starch does) more than others and are diffusible in it with different degrees of facility, that this diffusion is in part at least, analogous to that of colloids in water, that the strata observed in the suspension represent members of this series of chemical compounds which hold their different proportions of combined water very feebly and are stable under a very limited range of conditions. That they are destroyed or changed in the presence of acids, salts and various other compounds, and that they are stable only under certain conditions of temperature, some which may exist at one temperature being changed to others or destroyed at another temperature.

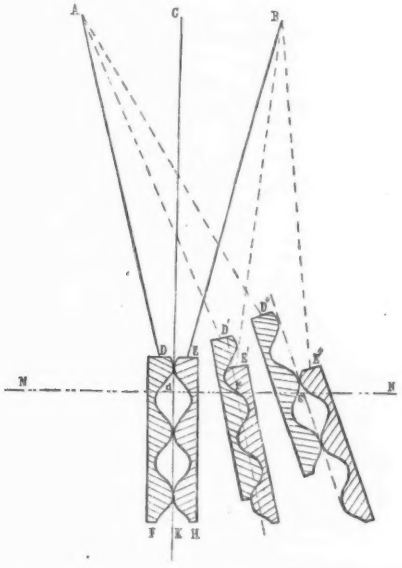
The special bearing of the experiments and conclusions on certain geological phenomena, especially the transportation of suspended mud and the formation of bars and deltas, will be considered in another paper.

ART. II.—*On a method of illustrating the formation of Diffraction Bands;* by S. T. MORELAND.

THE following method of illustrating the formation of bright and dark bands in diffraction phenomena has proved very satisfactory in my own teaching and I give it with the hope that others may find it useful. The method is shown in the accompanying figure, which hardly needs any explanation. A and B represent two luminous points from which start two disturbances having the same *phase* and the same *wave-length*. DF and EH are two pieces of thin board, one side of each having the form of a simple harmonic curve. DA and EB are two wires or cords of the same length. By moving the two pieces of board in the plane of the paper with the curved edges in contact and the wires always tight we readily find one series of points as *d* and *g* where crests coincide with crests. These points correspond to bright lines in diffraction. We also find another series of points, one between each two of those just mentioned as *f*, where crests coincide with troughs, and hence correspond to dark bands. The following are some of the laws of diffraction phenomena that may be proved, or at least illustrated, by this piece of apparatus:—

1. The distance between the bands increases as the distance AB diminishes. This is shown by simply varying the distance AB.

2. Other things being the same, the distance between the bands is greater the greater the *wave-length* of the light employed. This may be shown by having another pair of pieces representing a different *wave-length*. We may also infer the effect of using white light.



3. The bright points are so situated that the difference of their distances from the two centers of disturbance is a multiple of the *wave-length;* while for the dark points these differences are multiples of half the *wave-length*. Other points might be mentioned but these are sufficient.

No attempt has here been made to describe methods of getting the bands themselves by using light, because the necessary directions may be found in a number of books. Nor have I pointed out the limitations and inaccuracies in the method of illustration. These will readily occur to any one using it. So far as this piece of apparatus is concerned what I have assumed to represent a bright line might be taken for the dark one by making only a slight change in the pieces of board.

Lexington, Va.

ART. III.—*On a System of Rock notation for Geological diagrams;* by JAMES D. DANA.

IN geological diagrams it is often desirable that the kinds of rock should be indicated as well as their position. The following method of accomplishing this purpose is both simple and definite, and I think it will be found suited to general adoption. I have been led to the subject by the necessity of preparing many diagrams to illustrate an account of my recent observations on the stratigraphical relations of the Green Mountain formations.

In selecting the symbols, the fact that a sandstone is usually represented by a dotted surface suggested for quartz a dot (·); and another fact, that a slate or shale is indicated by parallel lining, suggested the use not only of such lining for shale or slate, but further of a short line like a hyphen (-) for mica; of a similar line three times as long (—) for hydrous mica (damourite, etc.), hydromica or sericite schist being intermediate in aspect between a slate and a mica schist.

To these symbols, I add a cross (+) for orthoclase feldspar; a cross in oblique position (×) for a triclinic feldspar or plagioclase; and the same cross with a line at bottom for a basic feldspar, andesite, labradorite or anorthite, when it is desirable to recognize the distinction.

The other more common of the essential constituents in rocks are hornblende, augite, hypersthene, chrysolite or olivine, leucite and glass. For hornblende an *n* is used; for augite, *u*; for hypersthene when a predominant constituent, *y*; for olivine, *v*; for leucite, *l*; for glass, *o*.

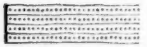
To distinguish thin schistose structure or slaty bedding, a rule is inserted between the lines of symbols; for thick schistose, gneiss-like, a rule is inserted at intervals of 2 to 4 lines of symbols; and for massive structure where bedding is recognizable, a rule at intervals of 6 or more lines of symbols or without rules.

No attempt is made to distinguish varieties of the different rocks dependent on accessory ingredients, as this would make the system cumbrous and impracticable. The following figures illustrate the method:

I. *Rocks whose essential constituents are quartz, mica, orthoclase, singly or in combination.*

1. Massive quartzyte (or quartzose sandstone).

2. Conglomerate.



3. Thin-bedded quartzyte (or sandstone).

4. Micaceous quartzyte.

5. Feldspathic quartzyte.

6. Phyllyte (argillyte).

7. Hydromica schist.

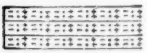
8. Quartzytic or arenaceous hydromica schist.

9. Very quartzytic hydromica schist.

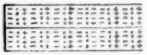
10. Mica schist (with little or no feldspar).

11. Quartzytic or arenaceous Mica schist.

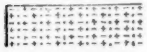
12. Very quartzytic Mica schist.



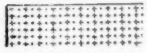
13. Gneiss, thin-bedded.



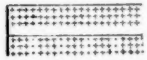
14. Gneiss, thick-bedded.



15. Granite.



16. Granulite (mica-less granite).



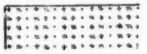
17. Felsyte.
18. Quartz-felsyte.

19. Trachyte.

20. Quartz-trachyte: same as 19, with the addition of the dot for quartz.
21. Gneissoid mica schist: same as 13 with the addition of a rule beneath each line of symbols.

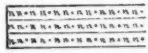
II. *Hornblendic rocks, containing hornblende alone, or with quartz or orthoclase, or with both.*

1. Syenyte.



2. Quartz-syenyte.

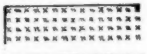
3. Hornblende schist.



4. Hornblende schist with little or no orthoclase.

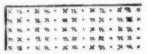
5. Hornblendyte without bedding: the symbol *n* without alternate rules.
6. Syenyte or hornblende gneiss: same as 2, with a rule at intervals of 2 to 4 lines of symbols.

III. *Rocks containing a triclinic feldspar (plagioclase) with hornblende, augite, hypersthene.*

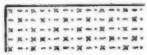


1. Dioryte.

2. Dioryte schist.



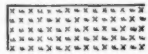
3. Quartz-dioryte.



4. Hemidioryte (mica-dioryte) containing quartz.

5. Labradioryte (labradorite dioryte), anorthite-dioryte

6. Andesyte.



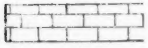
7. Augite-dioryte.

8. Doleryte, diabase, gabbro.

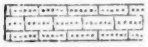
9. Hemidioryte without quartz (mica-dioryte): like 4 with the dot omitted.
10. Augite-andesite: like 6 with *u* in place of *n*.
11. Noryte: like 7 with *y* in place of *u*.
12. Dacyte: like 4 with the symbol for glass added.
13. Basalt: like 8 with the symbol for glass added.

The coarsely crystallized gabbro, common in Archæan regions, might be distinguished in symbol from doleryte or diabase by making the symbol for the basic feldspar of large size in proportion to the other letter. The typical euphotide of the Alps, etc., representing one section of gabbro, is a different rock in constitution in not containing a feldspar as a characteristic constituent, and should have a different symbol. Further, the symbol for an acidic plagioclase might be made distinct from that for plagioclase in general by adding a vertical line between the two upper bars of the cross.

IV. *Calcareous rocks.*



1. Limestone.



2. Quartzytic or arenaceous limestone.

3. Argillaceous limestone: like 2, with a line in place of the dots.

The above are examples of the proposed system of symbols. For rocks not included above, other symbols in accordance with the system may readily be devised, where the science requires them.

ART. IV.—*The Crystalline Rocks of the Scottish Highlands;* by ARCHIBALD GEIKIE.

EVER since the discovery of Silurian fossils in the rocks of Northwest Sutherland, it has been recognized that in that region lies the key to the structure of the Scottish Highlands. Accordingly, when in the progress of the Geological Survey, the mapping of the Highlands had to be undertaken, I determined that a detailed survey of the Sutherland ground on the scale of six inches to the mile should be made as a basis for the work. In the summer of last year a surveying party under the charge of Mr. B. N. Peach was stationed there, with instructions to begin by mapping the Durness Basin. This duty was satisfactorily accomplished before the end of the season. The Silurian series of Durness was ascertained to be about 2,000 feet thick, and to consist of numerous successive zones, which were traced on the six-inch maps and discriminated in such a way as to be recognizable should they be found to

occur in the more complicated region to the east. With this necessary groundwork well established, the Eriboll tract was attacked this summer by Messrs. Peach and Horne. I had never myself had an opportunity of studying the Eriboll sections, which, from the days of Macculloch down to the present time, have been such a fruitful subject of discussion. It was a special injunction to the officers now intrusted with the detailed survey of the region to divest themselves of any prepossessions in favor of published views and to map the actual facts in entire disregard of theory. By the close of this last season the structure of the Eriboll area had likewise been traced upon the six-inch maps, and I then went north to inspect the work. From time to time during the summer, reports had been made to me of the progress of the survey, but, though from the published descriptions of the tract, I was aware that its structure must be singularly complicated, and although apprised of the conclusions to which the surveyors, step by step and almost against their will, had been driven, I was hardly prepared for the extraordinary geological structure which the ground itself presented, or for the great change necessitated in the interpretation of the sections as given by Murchison.

No one cursorily visiting the ground could form any notion of its extraordinary complication, which could only be satisfactorily unravelled by patient detailed mapping such as had never yet been bestowed upon it. With every desire to follow the interpretation of my late chief, I criticised minutely each detail of the work upon the ground; but I found the evidence altogether overwhelming against the upward succession which Murchison believed to exist in Eriboll from the base of the Silurian strata into an upper conformable series of schists and gneisses. The nature of this evidence will be best understood from the subjoined report, which, at my request, Messrs. Peach and Horne have prepared. As the question of the succession of the rocks in the Northwest Highlands is still under discussion, I think it right to take the earliest opportunity of making this public declaration. It would require more space than can be given in these pages to do justice to the views of those geologists, from Nicol downward, by whom Murchison's sections have been criticised, and to show how far the conclusions to which the Geological Survey has been led, have been anticipated. When the official memoirs are published, full reference will be given to the work of previous observers, to which, therefore, no further allusion is made at present.

The most remarkable features in the Eriboll area are the prodigious terrestrial displacements, to which there is certainly no parallel in Britain. Beginning with gentle foldings of the rocks, we trace these becoming increasingly steeper on their

western fronts, until they are disrupted and the eastern limb is pushed westward. By a system of reversed faults, a group of strata is made to cover a great breadth of ground and actually to overlie higher members of the same series. The most extraordinary dislocations, however, are those to which for distinction we have given the name of Thrust-planes. They are strictly reversed faults, but with so low a hade that the rocks on their up-throw side have been, as it were, pushed horizontally forward. The distance to which this horizontal displacement has reached, is almost incredible. In Durness, for example, the overlying schists have certainly been thrust westward across all the other rocks for at least ten miles. In fact, these thrust planes, but for the clear evidence of such sections as those of Loch Eriboll, could not be distinguished from ordinary stratification-planes, like which they have been plicated, faulted, and denuded: Here and there, as a result of denudation, a portion of one of them appears capping a hill-top. One almost refuses to believe that the little outlier on the summit does not lie normally on the rocks below it, but on a nearly horizontal fault by which it has been moved into its place. Masses of the Archæan gneiss have thus been thrust up through the younger rocks and pushed far over their edges. When a geologist finds vertical beds of gneiss overlying gently inclined sheets of fossiliferous quartzite, shale and limestone, he may be excused if he begins to wonder whether he himself is not really standing on his head.

The general trend of all these foldings and ruptures is from north-northeast to south-southwest, and the steep westward fronts of the folds show that the terrestrial movement came from east-southeast. Corroborative evidence that this was the direction of the movement is furnished by a series of remarkable internal rearrangements that have been superinduced upon the rocks. Throughout the whole region, in almost every mass of rock, altogether irrespective of its lithological characters and its structure, striated planes may be noticed which are approximately parallel with the thrust-planes, and are covered with a fine parallel lineation, running in a west-northwest and east-southeast direction. These surfaces have evidently been produced by shearing. Again, many of the rocks near the thrust-planes, and for a long way above them, are marked by a peculiar streaked structure which reminds one of the fluxion-lines of an eruptive rock. The coarse pegmatites in the gneiss, for example, as they come within the influence of the shearing, have had their flesh-colored feldspar and milky-quartz crushed and drawn out into fine parallel laminæ till they assume the aspect of a rhyolite in which fluxion-structure has been exceptionally well developed. The gneiss itself coming into the same power-

ful mill has acquired a new schistosity parallel with the shearing-planes. Hornblende-rock has been converted into hornblende-schist. Moreover, new minerals have likewise made their appearance along the new divisional planes, and in many cases their longer axes are ranged in the same dominant direction from east-southeast to west northwest.

Murchison believed that the Silurian quartzites and limestones of Eriboll pass up under, and are conformably overlain by, his upper gneiss. It is quite true that they are so overlain; but the overlying rocks, instead of having been regularly deposited on them, have been pushed over them. What, then, are these overlying rocks? Though they have undergone such intense alteration during the process by which they were moved into their present position that their original characters have been in great measure effaced, lenticular bands occur in them which can certainly be recognized. Some of these bands are unquestionably parts of the Archæan gneiss; others are Silurian quartzite, and in one case we can detect a large mass of the Upper Durness limestone. Traced eastward, however, the crystalline characters become more and more pronounced until we cannot tell, at least from examination in the field, what the rocks may originally have been. They are now fine flaggy micaceous gneisses and mica-schists, which certainly could not have been developed out of any such Archæan gneiss as is now visible to the west. Whether they consist in part of higher members of the Silurian series in a metamorphic condition remains to be seen. The occurrence of a band of crystalline limestone and calcareous schist, which has been traced for many miles above the great thrust-plane, certainly suggests that it represents the upper part of the calcareous Durness series attenuated and altered by the intense shearing which all the rocks have undergone. This much at least is certain, that the schistose series above the thrust-plane is partly made up of Silurian strata, and has received its present dip and foliation since Silurian time.

Having satisfied myself that Murchison's explanation of the order of sequence could not be established in Eriboll, I was desirous to see again, in the new light now obtained, some of the Ross-shire sections for the description of which I am responsible. Had these sections been planned for the purpose of deception they could not have been more skillfully devised. The parallelism of dip and strike between the Silurian strata and the overlying schists is so complete as to prove the most intimate relationship between them; and no one coming first to this ground would suspect that what appears to be a normal stratigraphical sequence is not really so. But the clear coast-sections of Eriboll, where every dislocation is laid bare, have

now taught me that I have been mistaken, for the parallelism in question is not due to conformable deposition. The same kind of evidence of upthrust and metamorphism which these coast-sections reveal can be traced southward for a distance of more than ninety miles. The task of unraveling the geological structure of these southern regions will be much facilitated by the remarkable persistence of the Sutherland Silurian zones, some of which, with their characteristic features and fossils, are as well marked above Loch Carron as they are at Loch Eriboll.

In southwestern Ross-shire the platform on which the Silurian rocks rest is a thick mass of Cambrian red sandstone. In the great upthrow, it is this sandstone platform which has there been pushed over the limestones and quartzites. On the west side of Loch Keeshorn, the red sandstones, in their normal unaltered form, rise up into the colossal pyramids of Applecross; but on the east side, where, at a distance of little more than a mile, they overlie the limestones, they bear so indurated an aspect that they have naturally been classed with the quartzose members of the Silurian series. Traced eastward they present increasing evidence of intense shearing; fluxion-structure makes its appearance in them, with a development of mica along the divisional planes, until they pass into frilled micaceous schist, in which, however, the original clastic grains are still recognizable. They finally shade upward into green schists and fine gneiss which merge into coarse gneiss with pegmatite. The short space within which ordinary red feldspathic sandstone and arkose acquire the characters of true schists is a point of some importance in regard to the change from the unaltered Silurian strata of the Southern Uplands into the metamorphic condition of the Highland phyllites, grits, etc.

Obviously the question of chief importance in connection with the structure now ascertained to characterize the North-West Highlands relates to metamorphism. That there is no longer any evidence of a regular conformable passage from fossiliferous Silurian quartzites, shales and limestones upward into crystalline schists, which were supposed to be metamorphosed Silurian sediments, must be frankly admitted. But in exchange for this abandoned belief, we are presented with startling new evidence of regional metamorphism on a colossal scale, and are admitted some way into the secret of the processes whereby it has been produced.

From the remarkably constant relation between the dip of the Silurian strata and the inclination of their reversed faults, no matter into what various positions the two structures may have been thrown, it is tolerably clear that these dislocations

took place before the strata had been seriously disturbed. The persistent parallelism of the faults and of the prevailing northeasterly strike of the rocks indicates that the faulting and tilting were parts of one continuous process. The same dominant northeasterly strike extends across the whole Highlands, and also over the Silurian tracts of Southern Scotland and the north of England. There is reason to regard it in all these regions as probably due to one great series of terrestrial movements. These must have occurred some time between an early part of the Silurian period and that portion of the Old Red Sandstone period represented by the breccias and conglomerates of the Highlands. In the Central and Eastern Highlands the slates, phyllites, grits, quartzites, and limestones which, along the southern border, are scarcely more altered than their probable equivalents among the Silurian rocks of the Southern Uplands, have been greatly plicated, and have assumed a more or less crystalline structure. But when these changes were brought about, there lay to the northwest a solid ridge of Archæan gneiss and Cambrian sandstone which offered strong resistance to the plication. The thrust from the eastward against this ridge must have been of the most gigantic kind, for huge slices, hundreds of feet in thickness, were shorn off from the quartzites, limestones, red sandstones, and gneiss, and were pushed for miles to the westward. During this process, all the rocks driven forward by it had their original structure more or less completely effaced. New planes, generally parallel with the surfaces of movement, were developed in them, and along these new planes a rearrangement and recrystallization of mineral constituents took place, resulting in the production of crystalline schists. This metamorphism certainly occurred after early Silurian times, for Cambrian and Lower Silurian strata, as well as Archæan rocks, have been involved in it.

It is obvious that into the problems of Highland geology, always admittedly obscure, a fresh element of difficulty is introduced. At the same time the aid furnished by a minute study of the Sutherland sections is so great that we may hope to attack these problems with more success than has hitherto seemed probable. The work, too, is not of a kind to be attempted in a few hasty scampers over the ground. It will require patient, detailed mapping. But when the great baselines have once been accurately traced, the difficulties will doubtless begin to diminish, and, like the piece of a puzzle, the various segments of the Highlands will then be found to range themselves in their proper places.—*From Nature*, Nov. 13.*

* For extracts from the report of Messrs. Peach and Horne, and a stratigraphical section of the fault region, see beyond.

ART. V. — *Observations upon the Great Fault in the vicinity of Schodack Landing, Rensselaer County, N. Y.;* by S. W. FORD.

IN an earlier paper by the writer, upon the age of the rocks in the vicinity of Schodack Landing (this Journal for September, 1884), the exact course of the great fault referred to, or, in other words, the precise age of a ledge of slaty rocks a short distance south of the more southerly promontory therein described, was left in some uncertainty. The question was considerably complicated by the failure, in the first instance, to obtain fossils from the rocks in dispute, and, as will be seen further on, by the extraordinary position of the adjacent beds. I have recently spent several days in a careful study of the vexed locality, and in further examinations of the rocks of the neighborhood; and the additional facts obtained form the subject-matter of the present article.

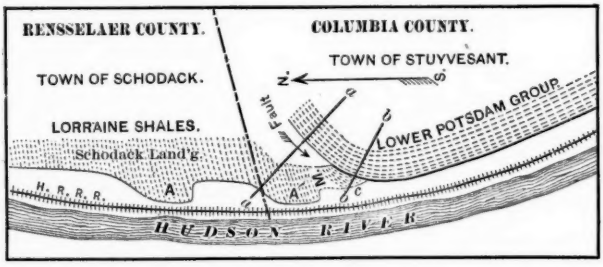
It is not often that one is permitted to observe the slates or schists of the early Cambrian overlying in apparent conformity those at the summit of the Lower Silurian, and yet such is the case in the locality which I am about to describe.* Along the western bases of Snake and Buck mountains in Vermont, and also in the hills east of Troy and Lansingburgh, New York, the evidences of a great fracture resulting in practically the same phenomena as those hereinafter mentioned are very conclusive; but in none of the localities cited has the actual contact of the older and newer groups been observed. In order to render the subject clearer to those who may be unacquainted with the region, I have introduced the annexed sketch-map, the geologically characterized portion of which represents a tract about three miles in length, with an average breadth of three-quarters of a mile. It lies, as will be noted, partly in Rensselaer and partly in Columbia county, along the eastern shore of the Hudson River.

The dotted area of the map represents that portion of the district occupied by the Lorraine Shales (= Hudson River Group),† and the particular portions of it, A, A′, the two prom-

* Judging from the life-history of the Trilobite *Olenellus asaphoides*, as at present known, I should infer that the Troy and Stuyvesant Primordial beds are somewhat more recent than the Georgia slates; but there is not, to-day, so far as I am aware, any evidence that would warrant their separation from them as a distinct group, or their assignment to an independent geological horizon.

† I have rejected the designation "Hudson River Group," for the reasons (1) that the rocks of this group constitute, in all probability, but a small proportion of the terranes east of the Hudson river to which the name was originally and especially applied; (2) that the term, as a geographical one, has come to be misleading, as will be seen by the map of the Schodack region; and (3) that it has been the source of nearly or quite as much trouble in American geology as the term Taconic. The old synonym, "Lorraine," stands for a well-characterized

ontories described in my former article. The rocks include shales and slates both fossiliferous and unfossiliferous; thick, gritty layers, one of which has afforded numerous specimens of *Orthis testudinaria* and *Leptæna sericea;* and one or more beds of limestone. Each of the promontories referred to contains a band of slates rich in graptolites, the best locality yet discovered occurring in promontory A, along the line of the Hudson River railroad, a few yards south of the flag-station at that point. Altogether this band has yielded fifteen species of graptolites, thirteen of which are well-known forms, and include *G. serratulus*, *G. divaricatus* and *G. Whitfieldi.* It has also furnished several specimens of a small *Lingula*, and an acephalous species probably identical with the *Lyrodesma pulchella* of Hall (Pal. N. Y., vol. i, p. 302, pl. 82, fig. 12). All of the beds have been greatly twisted and broken up, but their prevailing dip is eastward at high angles.



In its extension southward into Columbia county, the visible area of the Lorraine becomes somewhat contracted, and bears a little to the westward; and directly in front of Mr. Patrick McCabe's residence (M), it is completely cut off by a narrow marshy tract. Fifty yards south of Mr. McCabe's, however, a low ledge of similar rocks is met with, having a width at the northern extremity of a few rods, and a run to the southward of several hundred feet. The strike of the beds is a little east of north, the precise angle not determined. The slates of this ledge (*c*) have yielded the majority of the species of graptolites found in those of the promontories A and A′, and hence belong clearly to the same formation. At the date of publication of my former paper they had not been found fossiliferous.

Upon the southeast, the rocks of the ledge just described are immediately succeeded by a widely different group of strata, the fossils of which prove that they belong to the Primordial

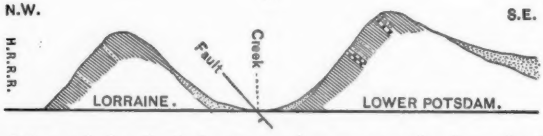
group in Jefferson county, and has the advantage, in its application to rocks of the same age east of the Hudson river, of leaving the other formations which there occur uncompromised; and for these reasons, and these alone, I have been led to adopt it in my work.

zone. This group is represented upon the map by the obliquely lined area. A brief description of these older rocks, by the writer, is contained in the July number of this Journal, for 1884, and since that time I have been able to increase but little the already published list of species found in them. Some distance south of the most southerly reach of the Lorraine, the Primodial strata begin to run inland; and, continuing this, finally sweep past the point *c* in a broad, northeasterly-bearing curve. In one favored locality, the lower slates of this group are found reposing fairly upon those of the Lorraine; and upon the phenomena presented at this point, I propose now to speak.

The locality referred to is situated nearly due south of Mr. McCabe's residence, and, by pacing, 210 yards distant from it. It may be easily found by going directly across the low ground in front of the house to the ledge *c*, and then taking the by-road southward along the edge of the hill. This road is only a few rods distant from the Hudson River railroad track. A small spring issues from the slates directly on the line of contact of the two groups; and although, at first sight, the older slates appear to conform perfectly with the newer, a closer examination shows that their cut edges, owing to the curve of the beds, really make a small angle with them. Moreover, the slates of the two groups are lithologically different, those of the Lorraine being, for the most part, black and carbonaceous, and some of them graptolitic up to within a few inches of the line of the overlap; while those of the Primordial are unctuous and highly micaceous, or, as Professor Dana informs me, may be true hydromica schists. There can be no doubt of the existence here of a great physical break, the course of which is indicated upon the map, by the continuous line bounding the Primordial area upon its western side.

In order to make the leading structural features of the region under consideration still better understood, I give below two sections, one of them along the line *a a* of the map and the other along the line *b b*. In the first of these (fig. 1), the pre-

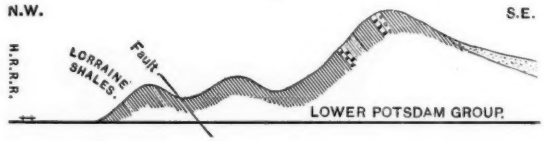
1.



cise position of the fault is somewhat uncertain, but the known facts strongly suggest that its indicated position is a close approximation to the truth. This section passes a little to the northeast of Mr. Wood's residence, in the town of Stuyves-

ant, in front of which, and all the way to the bottom of the ravine which it faces, the Lorraine beds are concealed by drift. The opposite slope is to some extent similarly mantled over; but the character of the underlying beds has been well ascertained.

2.



In the second section (fig. 2), the two groups are shown in contact with each other, and the fault is located with precision. Beyond this the section does not appear to me to call for special comment. On tracing the Primordial rocks eastward over the country, they are found to be arranged in a series of rather broad synclinal folds with apparently intervening denuded anticlinals. I have not yet attempted to trace out the course of the fault in its more eastward extension.

I have purposely dwelt at some length upon the structure of this remarkable region, partly because of the great interest which it possesses, and partly because of the efforts that have been put forth during the past two or three years, to banish from geology altogether what has, I believe, with good reason been denominated "The Great Appalachian Fault." These efforts have been grounded mainly upon the results of investigations conducted upon the west side of the Hudson river, and having no real bearing upon the question. One writer, in particular, whose views have appeared during the period referred to,* has pronounced the Great Appalachian Fault to be purely hypothetical, principally upon the strength of field-work done in the vicinity of Rondout; and a disposition seems to have sprung up in other minds, at about the same period, to advocate a similar view. To those who may have been led, either by their own investigations, or the researches of others, to so regard the matter, the region herein described is respectfully recommended, as one well calculated to conduct to the opposite conclusion.

Schodack Landing, N. Y., Oct. 30th, 1884.

* Mr. W. M. Davis, on "The Non-conformity at Rondout, N. Y." This Journal for November, 1883.

Art. VI.—*On the Cause of Mild Polar Climates;* by James Croll, LL.D., F.R.S.*

There are few facts within the domain of geology better established than that at frequent periods in the past the polar regions enjoyed a comparatively mild and equable climate, and that places now buried under permanent snow and ice were then covered with a rich and luxuriant vegetation. Various theories have been advanced to account for this remarkable state of things, such as a different distribution of sea and land, a change in the obliquity of the ecliptic, a displacement in the position of the earth's axis of rotation, and so forth. The true explanation will, I feel persuaded, be found to be the one I gave many years ago. The steps by which the results were reached were as follows:

The annual quantity of heat received from the sun at the equator is to that at the poles as 12 to 4·98, or, say as 12 to 5. This on the supposition that the same percentage of rays is cut off by the atmosphere at the equator as at the poles, which, of course, is not the case. More is cut off at the poles than at the equator, and consequently the difference in the amount of heat received at the two places is actually greater than that indicated by the ratio 12 to 5. But, assuming 12 to 5 to be the ratio, the question arose what ought to be the *difference* of temperature between the two places in question on the supposition that the temperature was due solely to the direct heat received from the sun? This was a question difficult to answer, for its answer mainly depended upon two things, regarding both of which a very considerable amount of uncertainty prevailed.

First, it was necessary to know how much of the total amount of heat received by the earth was derived from the sun and how much from the stars and other sources, or in other words, from space. Absolute zero is considered to be 461° below zero, Fahr. The temperature of the equator is about 80°. This gives 541° as the absolute temperature of the equator. Now were all the heat received by the earth derived simply from the sun, and were the temperature of each place proportionate to the amount directly received, then the absolute temperature of the poles would be $\frac{5}{12}$ of that of the equator, or 225°. This would give a difference of 316° between the temperature of the equator and that of the poles. According to Pouillet and Herschel space has a temperature of −239°, or 222° of absolute temperature. If this be the temperature of space, then only 319° of the absolute temperature of the equator are derived from the sun; consequently as the poles receive

* From the Phil. Mag. for October, 1884.

from the sun only $\frac{5}{12}$ of this amount of temperature, or 133°, this will give merely 186° as the difference which ought to exist between the equator and the poles. There is, however, good reason for believing that the temperature of space is far less than that assigned by Pouillet and Herschel—that, in fact, it is probably not far above absolute zero. Therefore by adopting so high a temperature as —239°, we make the difference between the temperature of the equator and that of the poles too small.

Second, it was necessary to know at what rate the temperature increased or decreased with a given increase or decrease in the amount of heat received. It was well known that Newton's law—that the change of temperature was directly proportionate to the change in the quantity of heat received—was far from being correct. The formula of Dulong and Petit was found to give results pretty accurate within ordinary limits of temperature. But it would not have done, in making my estimate, to take that formula, if I adopted Herschel's estimate of the temperature of space; for it would have made the difference of temperature between the equator and the poles by far too small. Newton's law, if we adopt Herschel's estimate of the temperature of space, would give results much nearer the truth; for the error of the one would, to a large extent at least, neutralize that of the other.

From such uncertain data it was, of course, impossible to arrive at results which could in any way be regarded as accurate. But it so happens that perfect accuracy of results in the present case was not essential. All that really was required was a rough estimate of what the difference of temperature between the equator and the poles ought to be. The method adopted showed pretty clearly, however, that the difference of temperature could not be less (although probably more) than 200°. But the present actual difference does not probably exceed 80°. We have no means of ascertaining with certainty what the mean annual temperature of the poles is; but as the temperature of latitude 80° N. is 4°·5, that of the poles is probably not under 0°. If the present difference be 80°, it is then 120° less than it would be did the temperature of each place depend alone on the heat received directly from the sun. This great reduction from about 200° to 80° can, of course, be due to no other cause than to a transference of heat from the equator to the poles. The question then arose, by what means was this transference effected? There were only two agencies available—the transference must be effected either by aerial or by ocean currents. It was shown at considerable length (Climate and Time, pp. 27–30, and other places) that the amount of heat that can be conveyed from the equator to the poles by

means of aerial currents is trifling, and that, consequently, the transference must be referred to the currents of the ocean. It became obvious then that the influence of ocean-currrents in the distribution of heat over the globe had been enormously under-estimated. In order to ascertain with greater certainty that such had been the case, I resolved on determining, if possible, in absolute measure the amount of heat actually being conveyed from the equator to temperate and polar regions by means of ocean-currents.

The only great current whose volume and temperature had been ascertained with any degree of certainty was the Gulf-stream. On computing the absolute amount of heat conveyed by that stream, it was found to be more than equal to all the heat received from the sun within 32 miles on each side of the equator. The amount of equatorial heat carried into temperate and polar regions by this stream alone is therefore equal to one-fourth of all the heat received from the sun by the North Atlantic from the tropic of Cancer up to the Arctic Circle.* Although the heating power of the Gulf-stream had long been known, yet no one had imagined that the warmth of our climate was due, to such an enormous extent, to the heat conveyed by that stream. The amount of heat received by an equatorial zone 64 miles in breadth represents, be it observed, merely the amount conveyed by one current alone. There are several other great currents some of which convey as much heat polewards as the Gulf-stream. On taking into account the influence of the whole system of oceanic circulation, it was not surprising that the difference of temperature between the equator and the poles should be reduced from 200° to 80°.

From these considerations, the real cause of former comparatively mild climates in Arctic regions became now apparent. All that was necessary to confer on, say Greenland, a condition of climate which would admit of the growth of a luxuriant vegetation was simply an increase in the amount of heat transferred from equatorial to Arctic regions by means of ocean-currents. And to effect this change of climate, no very great amount of increase was really required; for it was shown that the severity of the climate of that region was about as much due to the cooling effect of the permanent snow and ice as to an actual want of heat. An increase in the amount of warm water entering the Arctic Ocean, just sufficient to prevent the formation of permanent ice, was all that was really necessary; for were it not for the presence of ice the summers of Greenland would be as warm as those of England.

Were the whole of the warm water of the Gulf-stream at present to flow into the Arctic Ocean, it would probably

* Climate and Time, pp. 34, 35; Phil. Mag., February, 1870.

remove the ice of Greenland. Any physical changes, such as those that have been discussed on former occasions, which would greatly increase the volume and temperature of the stream and deflect more of its waters into the Arctic Ocean would, there is little doubt, confer on the polar regions a climate suitable for plant and animal life. At present the Gulf-stream bifurcates in mid-Atlantic, one branch passing northeastward into the Arctic regions, whilst the larger branch turns southeastward by the Azores, and after passing the Canaries re-enters the equatorial current. As the Gulf-stream, like other great currents of the ocean, follows almost exactly the path of the prevailing winds,* it bifurcates in mid-Atlantic simply because the winds blowing over it bifurcate also. Any physical change which would prevent this bifurcation of the winds and cause them to blow northeastward would probably impel the whole of the Gulf-stream waters into the Arctic seas. All this doubtless might quite well be effected without any geographical changes, although changes in the physical geography of the North Atlantic might be helpful.

These considerations regarding the influence of the Gulf-stream point to another result of an opposite character. It is this: if a large *increase* in the volume and temperature of the stream would confer on Greenland and the Arctic regions a condition of climate somewhat like that of Northwestern Europe, it is obvious, as has been shown at length on former occasions, that a large *decrease* in its temperature and volume would, on the other hand, lead to a state of things in Northwestern Europe approaching to that which now prevails in Greenland. A decrease leads to a glacial, an increase to an inter-glacial condition of things.

Sir William Thomson on Mild Arctic Climates.—In a paper read before the Geological Society of Glasgow in February, 1877, Sir William maintains also that an increase in the amount of heat conveyed by ocean-currents to the Arctic regions, combined with the effect of Clouds, Wind, and Aqueous Vapor, is perfectly sufficient to account for the warm and temperate condition of climate which is known to have prevailed in those regions during former epochs. The following quotations will show Sir William's views:—

"A thousand feet of depression would submerge the continents of Europe, Asia and America, for thousands of miles from their present northern coast-lines, and would give instead of the present land-locked, and therefore ice-bound Arctic sea, an open iceless ocean, with only a number of small steep islands to obstruct the free interchange of water between the North Pole and temperate or tropical regions. That the Arctic sea would, in such circum-

* See 'Climate and Time,' p. 213.

stances, be free from ice quite up to the north pole may be, I think, securely inferred from what, in the present condition of the globe, we know of ice-bound and open seas in the northern hemisphere and of the southern ocean abounding in icebergs, but probably nowhere ice-bound up to the very coast of the circumpolar Antarctic continent, except in more or less land-locked bays." . . . .

"Suppose now the sea, unobstructed by land from either pole to temperate or tropical regions, to be iceless at any time, would it continue iceless during the whole of the sunless polar winter? *Yes*, we may safely answer. Supposing the depth of the sea to be not less than 50 or 100 fathoms, and judging from what we know for certain of ocean currents, we may safely say that differences of specific gravity of the water produced by difference of temperature not reaching any where down to the freezing point, would cause enough of circulation of water between the polar and temperate or tropical regions to supply all the heat radiated from the water within the Artic circle during the sunless winter, if air contributed none of it. Just think of a current of three quarters of a nautical mile per hour, or 70 miles per four days, flowing towards the pole across the Arctic circle. The area of the Arctic circle is 700 square miles for each mile of its circumference. Hence 40 fathoms deep of such a current would carry in, per twenty-four hours, a little more than water enough to cover the whole area to a depth of 1 fathom; and this, if 7·1° Cent. above the freezing point, would bring in just enough of heat to prevent freezing, if in twenty-four hours as much heat were radiated away as taken from a tenth of a fathom of ice-cold water would leave it ice at the freezing point. This is no doubt much more than the actual amount of radiation, and the supposed current is probably much less than it would be if the water were ice-cold at the pole and 7° Cent. at the Arctic circle. Hence, without any assistance from air, we find in the convection of heat by water alone, a sufficiently powerful influence to prevent any freezing up in polar regions at any time of year."—*Trans. of the Geol. Soc. of Glasgow*, 22d February, 1877.

That an amount of warm water flowing into the Arctic Ocean equal to that assumed by Sir William Thomson, along with the effects of clouds, wind, dew, and other agencies to which he refers would wholly prevent the existence of permanent ice in those regions, is a conclusion which, I think, can hardly be doubted. It is with the greatest deference that I venture to differ from so eminent a physicist; but I am unable to believe that such a transference of water from intertropical and temperate regions could be effected by the agency to which he attributes it. Certainly the amount of heat conveyed by means of a circulation resulting from difference of specific gravity, produced by difference of temperature, must be trifling when compared with that of ocean-currents produced by the impelling force of the winds. Take, for example, the case of

the Gulf-stream. If the amount of heat conveyed from intertropical regions into the North Atlantic by means of difference of density resulting from difference of temperature were equal to that conveyed by the Gulf-stream, it would follow, as has been proved,* that the Atlantic would be far warmer in temperate and arctic than in intertropical regions. Taking the annual quantity of heat received from the sun per unit surface at the equator as 1,000, the quantities received by the three zones would be respectively as follows:—

Equator	1000
Torrid zone	975
Temperate zone . . .	757
Frigid zone	454

Assume, then, that as much heat is conveyed from intertropical regions into the Atlantic and Arctic seas by this circulation from difference of specific gravity as by the Gulf-stream, and assume also that one half of the total heat conveyed by the two systems of circulation goes to warm the Arctic Ocean, and the other half remains in temperate regions, the following would then be the relative quantities of heat possessed by the three zones:—

Atlantic in torrid zone . . .	671
" in temperate zone . .	940
" in frigid zone . . .	766

There is a still more formidable objection to the theory. It has been demonstrated, from the temperature-soundings made by the "Challenger' Expedition,† that the general surface of the North Atlantic must, in order to produce equilibrium, stand at a higher level than at the equator. In other words, the surface of the Atlantic is lowest at the equator, and rises with a gentle slope to well nigh the latitude of England. This curious condition of things is owing to the fact that, in consequence of the enormous quantity of warm water from intertropical regions which is being continually carried by the Gulf-stream into temperate regions, the mean temperature of the Atlantic water, considered from its surface to the bottom is greater, and the specific gravity less, in temperate regions than at the equator. In consequence of this difference of specific gravity, the surface of the Atlantic at latitude 23° N. must stand 2 feet 3 inches above the level of the equator, and at latitude 38° N. 3 feet 3 inches above the equator. In this case it is absolutely impossible that there can be a flow in the Atlantic from the equatorial to the temperate regions resulting

* 'Climate and Time,' Chap. xi; Phil. Mag., March, 1874.

† 'Climate and Time,' pp. 220–225; Phil. Mag., September and December, 1875; 'Nature,' November 25th, 1875.

from difference of specific gravity. If there is any motion of the water from that cause, it must, in so far as the Atlantic is concerned, be in the very opposite direction, viz: from the temperate to the equatorial regions.

All, or almost all, the heat which the Arctic seas receive from intertropical regions in the form of warm water comes from the Atlantic, and not from the Pacific; for the amount of warm water entering by Behring Strait must be comparatively small. It therefore follows from the foregoing considerations that none of that equatorial heat can be conveyed by a circulation resulting from difference of specific gravity produced by difference of temperature.

It is assumed as a condition in this theory that a submergence of the Arctic land of several hundred feet must have taken place in order to convert that land into a series of islands allowing of the free passage of water round them. But the evidence of geology, as was shown on a former occasion,* is not altogether favorable to the idea that those warm climates were in any way the result of a submergence of the polar land. Take the Miocene epoch as an example, all the way from Ireland and the Western Isles, by the Faroes, Iceland, Franz-Joseph Land, to North Greenland, the Miocene vegetation and the denuded fragmentary state of the strata point to a much wider distribution of Polar land than that which now obtains in those regions.

Mr. Alfred R. Wallace on mild Arctic Climates.—The theory that the mild climates of Arctic regions were due to an inflow of warm water from intertropical and temperate regions has also been fully adopted by Mr. Alfred R. Wallace. But, unlike Sir William Thomson, he does not attribute this transference of warm water to a circulation resulting from difference of density produced by difference of temperature, but to currents caused by the impelling force of the wind.

Mr. Wallace shares in the opinion now entertained by a vast number of geologists that during the whole of the Tertiary period the climate of the north temperate and polar regions was uniformly warm and mild, without a trace of any intervening epochs of cold. According to him there were no glacial or interglacial periods during Tertiary times. In this case he, of course, does not suppose that the inflow of warm water into Arctic regions, on which the mild condition of climate depended, was in any way due to those physical agencies which came into operation during an interglacial period. Mr. Wallace accounts for the mild Arctic climate during the Tertiary period by the supposition that at that time there were probably several channels extending from equatorial to arctic regions through the eastern

* Geol. Mag., September, 1878.

and western continents, allowing of a continuous flow of intertropical water into the Arctic Ocean. Mr. Wallace expresses his views on the point thus:—

"The distribution of the Eocene and Miocene formations shows that during a considerable portion of the Tertiary period an inland sea, more or less occupied by an archipelago of islands, extended across Central Europe between the Baltic and the Black and Caspian Seas, and thence by narrower channels southeastward to the valley of the Euphrates and the Persian Gulf, thus opening a communication between the North Atlantic and the Indian Ocean. From the Caspian also a wide arm of the sea extended during some part of the Tertiary epoch northwards to the Arctic Ocean; and there is nothing to show that this sea may not have been in existence during the whole Tertiary period. Another channel probably existed over Egypt into the eastern basin of the Mediterranean and the Black Sea; while it is probable that there was a communication between the Baltic and the White Sea, leaving Scandinavia as an extensive island. Turning to India, we find that an arm of the sea of great width and depth extended from the Bay of Bengal to the mouths of the Indus; while the enormous depression indicated by the presence of marine fossils of Eocene age at a height of 16,500 feet in Western Tibet renders it not improbable that a more direct channel across Afghanistan may have opened a communication between the West-Asiatic and Polar seas."—('*Island Life*,' p. 184.)

My acquaintance with the Tertiary formations of the globe, and with the distribution of land and water during that period, is not such as to enable me to form any opinion whatever either as to the probability or to the improbability of the existence of such channels as are assumed by Mr. Wallace. But, looking at the question from a physical point of view, it seems to me pretty evident that if such channels as he supposes existed, allowing of a continuous flow of equatorial water into the Arctic seas, it would certainly prevent the formation of permanent ice around the pole, and would doubtless confer on the arctic regions a mild and equable climate. This would be more particularly the case if, as Mr. Wallace supposes, owing to geographical conditions, far more of the equatorial water was deflected into the arctic than into the antarctic regions.

But at the same time I think it is just as evident that these channels would not neutralize the effects resulting from a high state of eccentricity. It may be quite true that the physical cause brought into operation during a high state of eccentricity might not be sufficient to reduce the quantity of warm water flowing into the Arctic Ocean to an extent that would permit of the formation of permanent ice around the pole, but

it certainly would greatly diminish the flow into the Arctic Ocean. Supposing that at the commencement of the last Glacial epoch the volume of the Gulf-stream to have been double what it is at present; this condition of things would not have prevented the operation of these physical agents which brought about the Glacial epoch, although it, no doubt, would have considerably modified the severity of the glaciation resulting from their operation. The very same thing would hold true, though perhaps in a much greater degree in reference to the channels assumed by Mr. Wallace.

If the emissive power of the sun was about the same during the Tertiary period as at present, and there is no good grounds for supposing it was otherwise, then the extra heat possessed by the northern temperate and arctic regions must have been derived either from the equatorial regions or from the southern hemisphere, or, what is more likely, from both. If so, then the temperature either of the southern hemisphere or of the intertropical regions, or both, must have been during the Tertiary period much lower than at the present day. A lowering of the temperature of the equatorial regions, resulting from this transference of heat, would tend to produce a more equable and uniform condition of climate over the whole of the northern hemisphere. As the area of the Arctic Ocean is small in comparison to that of the equatorial zone, from which the warm water was derived, the fall of temperature at the equator would be much less than the rise at the pole. Supposing there had been a rise of say 30° at the pole resulting from a fall of 10° at the equator (and this is by no means an improbable assumption), this would reduce the difference between the equator and the pole by 40°, or to half its present amount. We should then have a climatic condition pretty much resembling that which is known to have prevailed during at least considerable portions of the Tertiary period.

It is indeed very doubtful if such a climatic condition of things as that could be brought about by a high state of eccentricity with the present distribution of land and water; but, on the other hand, it is just as doubtful whether the channels of communication assumed by Mr. Wallace could have brought it about without the aid of eccentricity.

The very existence of so high a temperature on the northern hemisphere during Tertiary times may be regarded as strong presumptive proof that the geographical conditions obtaining on the southern hemisphere were most unfavorable to the flow of intertropical water into that hemisphere. This may be one of the reasons why a high state of eccentricity failed to produce a well-marked glacial epoch on the northern hemisphere, the geographical conditions preventing a transference of warm

water into the southern hemisphere sufficient to produce true glaciation on the opposite hemisphere. That the geographical conditions obtaining on the southern hemisphere during Tertiary times were probably of such a character is an opinion advanced by Mr. Wallace himself. "There are," he says, "many peculiarities in the distribution of plants and of some groups of animals in the southern hemisphere, which render it almost certain that there has sometimes been a greater extension of the antarctic lands during Tertiary times; and it is therefore not improbable that a more or less glaciated condition may have been a long-persistent feature of the southern hemisphere, due to the peculiar distribution of land and sea, which favors the production of ice-fields and glaciers." (p. 192.)

[To be continued.]

ART. VII.—*An attempt to determine the Amount and Rate of Chemical Erosion taking place in the Limestone (Calciferous to Trenton) Valley of Center County, Pa., and hence applicable to similar regions throughout the Appalachian Regions;* by A. L. EWING.

IN the following, the nature of the problem precludes the idea of even a close approximation to accuracy. It is claimed however that these determinations form a more reliable basis than mere estimates.

The method pursued is as follows: The amount of water flowing from a given hydrographic basin in the region under question is determined from the cross-section and velocity of the stream draining it. The amount of solids in the water is determined by evaporation; these data with the area of the basin form the basis of calculation.

The region selected is that of the Spring Creek basin which forms a considerable portion of the limestone valley of Center County. The measurements were made above the old dam below Bellefonte and below the entrance of all visible tributaries from the valley.

That a fair conception of the region may be had a brief explanation of its geology is necessary. The region under consideration forms a part of Nittany Valley. This valley, known under different names, extends through a considerable portion of the Appalachian region, and consists of the remains of a great anticlinal fold, which had it not been worn down would form an immense mountain-like plateau over 20,000 feet above its present height. As it is, the floor of the valley consists of the upturned edges of the lower Silurian limestone

eroded through a thickness of 6,000 feet. The valley is flanked on either side by the remnants of the overlying Medina Sandstone which forms monoclinal ridges from 600 to 1,000 feet above its floor. The inside slopes of these mountains are formed by the Utica and Hudson River shales.

The great amount of erosion that has taken place here is an interesting geological topic. That in early times it was mainly mechanical, caused by the steeper declivities, is undoubtedly true. The present topographical features, however, can not be explained without considering the excessive chemical erosion of the limestone. This I believe is the opinion of the geologists who have visited the region. The water from the limestone contains a large amount of calcium and magnesium salts. That from the State College well gives ·2273 grams per liter of solids, over 80 per cent of which are calcium and magnesium carbonates. Sink holes, caves, etc., are common as in other limestone regions. Still, I am not aware that any attempts have been made to determine the *amount of erosion* taking place by this process, and hence the following is submitted.

Average width of stream where the measurements were taken, 22·86 meters (75 ft.). Depth, average of six measurements across the bed of the stream, ·823 meters (2·7 ft.). This gives as the cross-section of the stream 18·81m² (202·5 sq. ft.). Allowance was made in these determinations for obstruction from weeds, etc.

The velocity of the stream was determined by floating surface particles and by floating a long bottle weighted with shot at various depths from ·3 m. to ·75 m. (the greatest depth of the stream being 1m.). The velocity of the stream was found to be 994·776 m. per hour, this giving 18·172m³, as the amount of water removed per hour. The water shows on evaporation, as average of two tests, 155·3 grams per m³, giving. 2,905,974 grams the amount of solids removed per hour, or 25,456,560 kilos. per annum. As the area of limestone drained by Spring Creek is about 100 sq. miles, this gives 255·654 kilos. of solids as the amount removed per annum per sq. mile. This is equivalent to 282 tons.

A portion of the water carried off by Spring Creek, however, falls not upon the limestone area considered above, but upon the mountains bordering the valley. Probably one-fourth of the water falls upon the mountains. To show that the main part of the solids comes from the limestone, I had specimens of the water as it flows from the mountains evaporated. An average of two tests gave 16·5 grams per m³, or a little over one-tenth of the amount found in the water as it flows from the valley. Thus not more than one-fortieth of the solids in the Spring Creek *water* probably comes from the mountains.

Making this correction it still leaves 275 tons per sq. mile as the amount annually removed in solution.

A closer approximation could be made by continuing observations similar to the above through a period of time, say for one year. To get the *amount of water* carried off in a year this would be necessary. Yet it is evident that the *amount of solids carried away in solution is much more constant than the amount of water flowing through the stream;* as in times of freshet or excessive flow there is a larger proportion of surface water, while in times of diminished flow a relatively larger portion of the water reaches the stream through underground drainage and must contain more solids. Hence the above number, 275 tons per sq. mile, may be taken as a fair approximation to the amount of material actually removed per annum in this and similar regions.

According to the above determinations and assuming that the solids removed have a specific gravity of 2 8, we get as the cubic contents of the mass removed from the entire basin 9,130·5m³, or 91·3m³ per sq. mile per annum, making the deduction as before of one-fortieth for the amount brought from the mountains; and conceiving the remainder to be spread evenly over the surface it would form a layer $\frac{1}{29173}$ of a meter in thickness. Hence to lower the surface to the extent of 1 m. by this process would require 29,173 years, or about 9,000 years to remove one foot from the surface.

It is safe to assume that had the rocks of this region been similar to those of the bordering mountains in their nature and power to resist dynamical agencies we should have in place of Nittany valley a mild anticlinal plateau somewhat above the mountains in elevation, say 1000 feet above the present height of the valley. The erosion in the valley then in excess of that along the mountains has been mainly chemical and at least 1000 feet of limestone has been thus removed. A simple further deduction shows that accordingly Nittany valley has been 1,000,000 years in process of formation.

The *limestone erosion* could not begin before the latter stages of the Mesozoic era, possibly not before the Cenozoic era, as sufficient time must have elapsed subsequent to the Carboniferous age to erode all formations of the Paleozoic era above the Trenton limestones. One million years seems not inconsistent with other estimates of geological time; still these calculations respecting time are an afterthought and supplementary to the main point intended to be shown in this paper, viz: the rate and amount of chemical erosion of limestone.

Art. VIII.—*On the Chrysotile from Shipton, Canada;* by Erastus G. Smith, PhD.

There has recently come into my possession, through the kindness of Mr. W. H. Jeffreys of Richmond, several specimens of the fibrous variety of serpentine or chrysotile from the above named locality. So well characterized were the specimens, and diligent search failing to discover any analyses or description of the properties of the mineral from this locality, an examination was instituted with results appended below.

Serpentine is commonly met with through many portions of the Province of Quebec, occurring either as large deposits of the comparatively pure mineral or more generally mixed with other minerals, notably calcite and chromite. Chromite especially appears to be almost always present in the serpentine of the Silurian rocks.

The fibrous variety of serpentine or chrysotile generally spoken of as "asbestus," appears to be distributed also in almost unlimited quantities through many of the southeastern townships, notably at Thetford and Coleraine. (See Report of Geological Survey of Canada, 1881–82, G.G., pp. 6–8).

The chrysotile from Shipton seems to be of much the same character both in appearance and mode of occurrence. It occurs in narrow veins of from one to four inches in width traversing the solid serpentine. These veins possess little or no regularity, often abruptly terminating. The fibers run transversely, improving in quality as the mineral recedes from the surface of the ground. In appearance the chrysotile has a fine silky luster, varying in color from a deep green to a pale yellow. The fibers can be easily separated from each other, forming a soft voluminous wool-like mass. Before the blow-pipe it is fusible only with the very finest fibers. It yields water readily on ignition, being at first blackened and finally assuming a dull brown color. The ignited mass loses its fibrous character and crumbles easily beneath the fingers. The reaction for iron is always marked and *with some specimens that for chromium also*, though as will be noticed, the particular specimens analyzed gave *no* chromium reaction. This variable reaction is accounted for by the fugitive presence of chromite in the vicinity, which as already noted, so often accompanies the Canada serpentines.

Two specimens were selected for analysis: I. Dark green, sp. gr. 2·142 (temp. 16° C.). II. Pale yellow, sp. gr. 2·286 (temp. 16° C.).

	I.	II.
SiO_2	41·837	42·043
FeO	2·234	3·663
MgO	41·990	39·540
H_2O	14·282	14·309
	100·343	99·555

These analyses establish clearly the identity of this mineral with the chrysotile from other localities, as can be readily confirmed by comparing them with the analyses already published.

Chemical Laboratory of Beloit College, Beloit, Wisconsin, Nov. 28, 1884.

ART. IX.—*The Santa Catharina Meteorite;* by ORVILLE A. DERBY.

HAVING recently undertaken, in company with Mr. Luiz Gonzaga de Campos, an examination of the Brazilian meteorites preserved in the National Museum of Rio de Janeiro, in which that gentleman has taken charge of the chemical and I of the physical part of the work, I have had occasion to make the following observations on the somewhat famous Santa Catharina meteorite which seem to be of sufficient importance to warrant publication in advance of the more extended general memoir that we are now preparing.

M. Daubrée, who has so thoroughly studied the metallic portion of this meteorite, mentions an ochreous crust in some of the specimens* which he took to be of secondary and terrestrial origin, and to be composed of a mass of limonite resulting from the oxidation of the iron, together with imprisoned fragments of the disintegrated granite on which the mass was stated to have rested. Misled by this conclusion (a very natural one if, as is to be presumed, the crust on the specimens examined was partially decomposed), he devoted all his attention to the metallic elements with the brilliant results that are so well known. This crust, however, when examined on well preserved specimens, proves to be an essential part of the meteorite, in nothing inferior in interest to the metallic portion. Aside from the many interesting points of structure it presents in itself, it affords the best of proofs that the mass is really of meteoric origin, a matter which the peculiar properties of the iron had placed in doubt. Moreover, it appears to indicate the existence of a new group of meteorites intermediate in character between the holosiderites (composed wholly of iron) and the syssiderites (with stony portions disseminated in a spongy

* Comptes Rendus, vol. lxxxiv, p. 1508. Études synthétiques de Géologie Expérimentale, p. 536.

metallic mass) of Daubrée, or perhaps rather it should be said that it throws new light on the real structure of the former.

This crust has been observed in two forms, which, from the aspect presented macroscopically, may be called provisionally, the granitoid and the porphyritic. Although the former has not, like the latter, been observed adherent to the iron, it is evidently the primitive form and will be described first. It consists essentially of olivine in small glassy crystalline fragments and of plagioclase feldspar (apparently anorthite) in grains up to 6 or 8 millimeters in diameter. It is traversed by fine veinlets of black limonite which has also stained the mass red so that it presents the appearance of ordinary half decomposed granite. Under the microscope it has the aspect of a porphyry, the clear grains of olivine and such of the plagioclase as has escaped decomposition standing out brilliantly in a dark opaque groundmass consisting of limonite and of decomposed feldspar, and perhaps also of other decomposed silicates and of an original glassy groundmass, if the rock contained them. The olivine grains are beautifully clear but much fractured, showing along the cracks a yellow discoloration which occasionally presents a beautiful botryoidal appearance. The specimens of this rock have unfortunately been hammer-dressed, so that they show nothing of the original surface. They represent, however, a thickness of several centimeters at least. No grains of metallic iron have thus far been detected in them, but as points of the rock exert a slight influence on the magnetic needle, their presence is suspected. Minute grains that appear to be magnetite have been separated with the magnet, but have not yet been examined. The porphyritic rock forms a crust, 1 to 2 centimeters thick, completely enveloping an oblong rounded mass of iron, 18 centimeters long and 10 centimeters in diameter. This crust scales off readily, taking always a portion of the iron with it. Small fragments of iron are also scattered through it. The surface of this crust being somewhat decomposed and ochreous, the appearance of the entire mass, which may be called a meteoric individual, as it has evidently not been broken from a larger mass since the fall, is that of the concretionary masses of limonite common in decomposed granite and elsewhere. This is a true porphyry consisting of grains of olivine with rare fragments of plagioclase scattered in a dark glassy groundmass which can only with difficulty be rendered transparent, when it presents a light reddish color. The mass is somewhat scoriaceous from the presence of numerous rounded cavities, and the glass presents a fluidal structure. The feldspar has much the same appearance as in the granitoid form, that is to say, a clear nucleus surrounded by an opaque portion. The nucleus, however, is

not troubled as in that rock, and the opacity is, in this case, evidently due to vitrification of the margins of the grain, and not to decomposition as in the case of the granitic rock.

In order to verify the idea that was at once suggested, that this porphyritic rock was the result of the partial fusion of the granitoid, I attempted to reproduce the peculiarities it presents. Taking quartz to represent the infusible element and labradorite for the fusible, I made a mixture of these minerals broken into small fragments, but not ground, adding some scraps of iron turnings and fragments of magnetic pyrites. After an incomplete fusion, the characters above mentioned were found to be very satisfactorily reproduced. The principal differences noted were that the glass was clearer and that those grains of feldspar which escaped complete vitrification were, for the most part, more troubled, many of them becoming quite opaque and with an abundant development of microlites.

It appears therefore that this meteorite presents a mixture of metallic and siliceous elements combined in a way that has not hitherto been noticed, and that the stony portion also presents a new type of structure in which olivine and plagioclase are the predominant elements. The partial vitrification of the stony portion seems to afford unequivocal evidence of the meteoric origin of the mass. The presence of silicates, in part fusible, which would form a crust of low conducting power about the iron will enable us to account satisfactorily for the low magnetism of portions of the mass noted by Lawrence Smith and Becquerel,* which led them to infer that the iron had crystallized below a red heat, a fact which it would be difficult to reconcile with the incandescence of meteorites, if the mass had been composed exclusively of metal. It ma be reasonably inferred that different portions of the mass will be found to vary in magnetic properties. It is hoped that material for investigating this and other questions may be obtained in a visit which Mr. Campos will shortly make to the place of fall for the purpose of collecting facts for the full history of this interesting meteorite.

The observations here presented suggest the suspicion that other large iron meteorites may present something analogous, and it is hoped that an opportunity may shortly be afforded for examining the famous Bemdego meteorite which, judging from the descriptions of Mornay and of Spix, and Martius, contains stony portions. The former mentions a crust on the lower portion, and the latter state that it rested on a mass of granite fragments, which, in view of the above facts, may be suspected to have belonged to it. Both mention masses of quartz embedded in the iron which are most probably of olivine.

* Comptes Rendus, vol. xciii, p. 794, 1881. This Journal, March, 1882.

ART. X.—*The Gravels of the Southern Delaware Peninsula;* by FREDERICK D. CHESTER.

IN a former number of this Journal (March, 1884), under the title of "*The Quaternary Gravels of Northern Delaware and Eastern Maryland,*" the writer described those deposits known as the Red Sand and the Philadelphia Brick Clay, which cover to great depths the underlying formations of New Castle and Cecil Counties. Later investigations in connection with a geological survey of Delaware lead us to consider the surface deposits of the peninsula as a whole; and, although this paper is intended as a continuation of the other, it will be necessary, first, to review very briefly some of the facts previously brought out, before describing in detail the phenomena of the southern area. The surface formations of the peninsula may be classed as follows:

1. High Level or Bryn Mawr Gravel ..... Cretaceous?
2. Delaware Gravels .... { Red Sand. / Philadelphia Brick Clay. } Quaternary.
3. Estuary Sands ..... Quaternary.
4. Bog Clay ..... Modern.

A REVIEW OF THE NORTHERN AREA.

High Level Gravels.—In traveling over the highlands of Northern Delaware, just back of the old terrace line of the succeeding Post-Glacial formation, one is liable to come upon solitary patches of gravel, varying in area from a few hundred square feet to several acres. They do not always form strata of definite depth, but often the rounded pebbles are found mixed with a predominating quantity of angular material, *in situ*, while again, in other places, a well defined deposit may be traced, as in the northeast part of the State, over a large area of several square miles. The gravel is made of highly water-worn quartzose and quartzitic pebbles, associated with a considerable amount of ferruginous grit and conglomerate.

As regards the position and extent of these isolated patches, there seems to be no law, but capping as they do the highest points of the hills, which rise from 350 to 400 feet above tide water, it is probable that they represent the remnants of a once continuous patch. The same formation, as shown by other geologists, extends over the heights of Southeastern Pennsylvania, Southern New Jersey, and the District of Columbia, indicating a considerable ingress of the sea shore line. As far as Delaware is concerned, we can say, that during the Bryn

Mawr period the State was submerged to a great depth, probably much greater than the maximum limits in Delaware indicate. The exact outline of this old sea, extending far within the bounds of other States must be traced, as it will be, by the work of the several geologists engaged upon this particular field, and the results will be eagerly looked for.

The question of the age of the High Level Gravels is one of much interest. The extreme erosion which they have suffered, that isolated patches might be produced, is alone sufficient proof of their great age. If they once formed a continuous layer, covering the tilted Archæan rocks, thew hole topography of that area must have been produced since their deposition—the depth of erosion in Delaware amounting to a maximum of 300 feet. Prof. W. M. Fontaine has described * a similar gravel found covering the Azoic areas of Virginia. It occurs as solitary patches along the western margin of all the interior belts of the Mesozoic, the materials being bowlders and conglomerates of the Potsdam, Azoic and Mesozoic rocks, imbedded in a stiff clay. That these patches represent the eroded edges of Mesozoic strata, would be gathered from Professor Fontaine's statements. The origin of the materials, particularly the large bowlders, is supposed to be from glaciers descending the eastern slopes of the Alleghanies in later Jurassic time. The same gravel is said by Professor Fontaine to extend as far north as the heights around Washington, where it is known to be contemporaneous with the high level gravel of Delaware and Southeastern Pennsylvania. Thus we have one continuous line of gravel patches bordering the western edge of the Mesozoic and extending from Virginia to New Jersey. The careful labors of Mr. W. J. McGee of the U. S. Geological Survey upon the High Level Gravels in the neighborhood of Washington are quite in accordance with the view of their late Jurassic or Lower Cretaceous age, although the writer does not feel at liberty to make any special use of Mr. McGee's results previous to their publication.

Mr. C. E. Hall in his Report on Southeastern Pennsylvania has expressed the view that the Mesozoic strata lying to the southeast once extended far to the northwest, so as to overlie the Azoic, and that these isolated patches may represent the remnants of this former extension. Thus far I think, that in absence of direct evidence regarding the age of the gravels we are led to regard them as more probably of late Jurassic or early Cretaceous.

Considering again the great erosion which the High Level Gravels have suffered, it is interesting to enquire into what has become of the portion removed. No doubt it has suffered re-

* Mesozoic Strata of Virginia. This Journal, III, vol. xvii, p. 31.

deposition by the waters of succeeding time. The writer has consequently looked throughout the Tertiary for evidence bearing upon this point, and has been to some degree successful. From numerous records of well-diggings, it is found that fragments of similar grit, called by the people "iron ore," are seen in the white Tertiary sand, but whether they are re-deposited Bryn Mawr is a point upon which the utmost confidence cannot as yet be placed. Yet the abundance of well rounded fragments of conglomerate everywhere throughout the Delaware Gravels points in numerous cases to indisputable Bryn Mawr origin. The great difficulty, however, in the way of recognizing such identity is their confusion with similar fragments formed at present by the action of ferruginous waters upon sand and pebbles, but particularly by the segregation of crusts within the substance of quartzitic bowlders. Notwithstanding these difficulties there can be little doubt but that many of the representatives of the Delaware Gravels had their source in the older High Level formation.

Delaware Gravels.—Passing along the slope of the old Azoic hills, which trend in a northeast and southwest direction, between the Delaware and the Susquehanna rivers, a distinct terrace line can be traced, rising upon an average of 200 feet above the river, but increasing in its altitude toward the west and presenting throughout its entire length a more or less ragged outline, due to the subsequent decay of the hill-slopes upon which it rests. This shore line marked, as we know, the head of a Post-glacial estuary, into which the swollen Delaware poured its mass of *debris*. The deposit thus made, purely fluviatile in origin, yet spread over an estuary floor, we have called the *Delaware gravels*. It consists, as we have seen, of an upper layer of brick clay containing in most cases a large amount of fine and coarse gravel, cobble stones, and bowlders, with many features characteristic of the bowlder clay and having a uniform thickness of from two to three feet. Beneath this is a thick stratum of highly ferruginous sand and gravel, exhibiting eminent stratification, with oblique laminations, or flow-and-plunge structure, having an average depth of twenty-five feet. These *Delaware gravels* are spread out from the shore-line over all the northern part of the peninsula, of which a detailed description has already been given.

Bog Clay.—By passing up and down the Delaware River, one notices at a variable distance of from one-quarter to a couple of miles, a low terrace, having an altitude above the river of from twenty to thirty feet. Its course is usually very winding, sometimes bending almost to the river, and again extending far inland and winding around so as to form broad and deep enclosures. This secondary terrace line is but an

abrupt termination of the rolling gravels extending down from the upland terrace. It marks the last stage in the retreat of the estuary waters. Beneath this lowest terrace and that terrace some 200 feet higher up and several miles to the north, are traced a number of indistinct intermediate terrace lines. One of these, rising some sixty feet above the river, can be followed from Wilmington for twenty miles or more to the south, keeping for the greater portion of its length the course of the Delaware railroad. From the lowest river terrace of red gravel, the same deposit is seen to dip beneath a uniform bed of black clay, and is always struck in the digging of deep drainage trenches along the shore. A deposition of the same bog clay is now going on by means of flood-tide, whenever the land is unprotected by earth dikes. It is this impervious layer which forms the basis of all the undrained marsh land of the river and bay shore.

Phenomena of the Southern Area.

General considerations. — Beginning with the latitude of Appoquinimink Creek, which marks the southern boundary of New Castle County, Del., and extending to the lowermost limits of the peninsula, we have an area comprising over four-fifths of the entire peninsula. Yet so much of what is observed within the larger territory being but a repetition of what occurs to the north, the subject of the gravels, in the way it is treated, is about equally divided. Generally speaking, we may say that from the northern limit above indicated to about the latitude of Dover, the region is covered by both members of the *Delaware gravels*, with their usual thickness well maintained throughout. They are very morainic in their characters, rising into elevations sometimes reaching fifty feet, with corresponding depressions. Over the surface everywhere are scattered an abundance of bowlders, large and small, the upper brick clay becoming a stratum of coarse gravel or bowlder clay. As we pass to the south of Dover, however, appearances change, the country becomes gradually less undulating, and the gravels less coarse, the change being indeed so gradual as to be imperceptible. At a distance as far south as Murderkill Creek, the lower red sand, instead of being a coarse gravelly stratum, is a uniformly coarse sand of the same color, and comparatively free from gravel. It is always overlaid with a foot or two of white sandy loam, free from coarse gravel, but containing smaller rounded pebbles of glassy or jaspery quartz and quartzite, together with subangular fragments of chert and hornstone, the latter being often fossiliferous. Covering the surface of the sandy loam, quartzitic bowlders are found,

but in less abundance than over the northern area. As we continue southward, even *to the utmost limits of the peninsula*, the country becomes nearly flat, the red and brown sands change to a lighter color, until quite white, in which case the two members of the gravels merge into each other. At numerous localities within this region of white sands, however, the latter become distinctly red and brown with so large an admixture of gravel as to become identical with the red gravels of New Castle County, in which case there is always an overlying layer of white loam bearing upon its surface the characteristic bowlders. Often, again, we see one thick stratum of white sand, in which are streaks of red in varying quantity, while oftener still, the white sand assumes a slightly reddish tinge.

Origin of the Southern Sand and Gravel.—From the above facts, there can be no doubt but that the white sands which cover over one-half of the area of the peninsula are contemporaneous with the *Delaware gravels;* but the two differ entirely as regards origin. While the *Delaware gravels* were a fluviatile deposit spread out over the upper portion of the estuary floor, the white sands were of marine origin, the deposition taking place at the broad mouth of the estuary and at a considerable distance out in the open sea. The probable truth of this statement is further shown by the finding of modern marine shells in the lower part of the white loam, near its junction with the tertiary blue clay, of which mention will be made shortly.

To account for the intimate mingling of the red gravel with the white sands, we suppose that as the red gravel from the north met the morainic sands of the south, the two became mixed, thus producing a gradual merging of the one into the other. Further, outcoming tides would carry loads of the fluviatile red gravel far to the south, where it would become interstratified with the white sand.

This lower deposit of white sand and gravel we shall designate the *Estuary sands.*

Professor J. C. Booth, in his Report upon Delaware (1841), attributed the white estuary sand to the destruction of ancient dunes which have gradually been blown far inland. The basis of that theory was the finding of dunes as far to the west as the town of Seaford, and the observation there and elsewhere of a similarity between these sands and those which formed the universal covering. This hypothesis is, I think, a mistaken one. In the first place, dune sand is entirely free from fine and coarse pebbles. A careful study by the writer of the dunes of the coast revealed no pebbles even as large as one-half inch in diameter, while the estuary sands revealed everywhere an abundant mixture of pebbles of this size with a

smaller quantity of quartzitic pebbles from one-half to three inches in diameter; and in still rarer cases, as at Milford and Seaford, cobblestones and small bowlders have been dug out of the white and red sand deposit. Bowlders are, furthermore, everywhere found covering the surface of the estuary sands to even the southernmost limit, some of the largest being found at Snow Hill, Md. They therefore must have been dropped by ice-rafts borne upon the waters of the Post-Glacial estuary, in which were deposited the white sand and gravel upon which they lie. In the neighborhood of Seaford, one may readily perceive the relation of the dunes to the estuary sand.

While the former are extremely loose and fine, free from even the smallest pebbles, the latter is a rather coarse loam, containing enough clay to hold it together and sometimes to pack hard, mixed with a due proportion of fine gravel. Instead of the meridional sand hills having been produced by the blowing in of that material from the sea, it seems more probable that they were made by the shifting and accumulation of the finer particles of the estuary deposit. As the surface of this sand stratum becomes dry, there is seen to form a thin film or efflorescence of fine white sand which the writer has observed is readily taken up by the wind and shifted in various directions. Any slight obstacle, such as a fallen tree, would form a barrier or nucleus of accumulation, from which might grow a dune of considerable size. This must appear to any careful observer the origin of the interior dunes of the Delaware peninsula.

The age of the Estuary sands.—The estuary sands forming a stratigraphical continuation of the *Delaware gravels* are contemporaneous with them, while this latter material, finding its source in the fluviatile gravels of the Delaware river valley, is undoubtedly Post-glacial, especially as the vast amount of bowlder drift associated with it can have none other than an iceberg origin. But, besides this proof of age, we have that which is still more certain.

In the lower part of the estuary sands near its junction with the clay have been found nests of modern shells, of which the most common species is the modern oyster (*O. Virginica*). These have been found in some four or five localities of Sussex County. Near Dagsborough a nest of broken fragments of the oyster shell was found, with which were also well preserved specimens of the *Tritia trivittata* and *Urosalpinx cinerea*, well-known littoral gastropods still living upon the Atlantic coast. In Baltimore Hundred the oyster shell was found associated with *Venus mercenaria* and *Fulgur canaliculatus*. For an examination of these modern shells from the *Estuary sands*, I am indebted to Professor Angelo Heilprin.

Local details.—In the vicinity of Smyrna and from the westward to the State boundary, the Delaware Gravels become unusually coarse, attaining a thickness of from 30 to 35 feet. The bowlders, cobble-stones and pebbles are of both glassy and quartzitic varieties, the latter running into a ferruginous conglomerate and sandstone. Two miles west of Clayton one bowlder of conglomerate was found to measure $3' \times 2' \times 1'$, with which were subangular fragments of coarse granite and cellular quartz similar to buhrstone. At Dover the same coarse gravels continue, and rise as moraines of considerable size. A fresh cutting within the limits of the town gave the following section:—

1. A black sandy loam ..... 9″—6″
2. A sandy brick clay ..... 1·5′
3. A red sand compactly bedded ..... 25′
4. A blue clay—Tertiary. .....

Along Jones Creek the gravels rise as high bluffs, and can be well studied. The pebbles are usually quartzitic, very commonly finely laminated, but with a considerable admixture of the glassy varieties, also yellow and black jasper. The less common pebble and bowlder representatives are—red, yellow and brown friable sandstone, fragments of pudding stone and ferruginous grit, gneiss, granite, trap, and white compact crystalline limestone.

Very commonly over the surface are found rounded and subangular pebbles and slabs of a greenish or brownish argillaceous sandstone, very similar to the Chemung. They frequently contain excellent specimens of the *Spirifer mucronatus*, and one piece exhibited to the writer a species of *Leptæna*. Another slab showed markings which appeared to be indisputable glacial scratches. At the Dover railway station, in a fresh cutting, the red sand showed beautiful examples of both oblique laminations and flow-and-plunge structure. Well rounded bowlders of both vitreous quartz and quartzite are common, many of them weighing not less than 500 pounds. Between Harrington and Milford, we are well within the region of white sands, but adjacent to Milford the red sand is abundantly interstratified with the white with which are also occasional seams of coarse pebbles, thus giving the deposit a highly gravely aspect. At Bridgeville, the interstratified seams of red sand are equally well developed, but the usual surface deposit is a coarse gray sand which here attains a thickness of over twenty feet. At Seaford, a little farther south, the gray sands reach an equal thickness. At the railway station of the above place we got the following section:—

1.	Red and white sand	5′
2.	Quartzitic pebbles	2″ ±
3.	Red sand	4′
4.	Irregular layer of pebbles—level of run	3″

Passing to the east of both Seaford and Bridgeville, and to the neighborhood of Georgetown, the white sand maintains the same character, but shows less thickness, varying from 3 to 15 feet with an average of about 8. Between Georgetown and Lewes, the sands are commonly of a slightly reddish tinge, running into white, and again into sand of a distinctly red or brown color. Three miles from Georgetown the road to Lewes cuts through a hill of coarse gravel, which, trending for several miles in a N.W. and S.E. direction, attains a height of fifty feet. Another similar hill of coarse gravel is found to the east of Ellendale. These are, in both cases, but swellings in the white sand and only differ from the latter in the large admixture of coarse pebbles, varying in size from one to three inches in diameter. In passing to the south of Georgetown, nothing new can be learned by citing localities. The surface stratum is a uniformly white or reddish-white sand having a thickness of from 6 to 10 feet, with generally a small proportion of fine gravel. At nearly all points, however, bowlders are found. At Snow Hill, Md., these bowlders are of frequent occurrence and have been collected into waste piles. They vary in weight from a few pounds to more than a man could lift. Among the rock species we may mention yellow jaspery quartz, brown conglomerate, a light granitic gneiss, a dark hornblendic gneiss, a coarse grained highly feldspathic granite, a dark blue slate rock and quartzite. A close study of the numerous bowlders at this point showed some indisputable evidences of glacial scratches, the most pronounced instance being a large well rounded bowlder of dark green diorite, the smooth surface of which was covered with very fine scratches, clearly of glacial origin.

Neck Lands.—This name is given to that slip of low marshy land which borders the bay shore. Its basis is an unpenetrated stratum of blue or black clay in which have sometimes been found by those living in the vicinity nests of modern oyster and clam shells. The deposit is identical with the bog clay of the river bank; so that we may say that from Wilmington to the southern line of the State into Maryland, the river and bay are edged with a belt of modern bog clay, varying in width from one to three miles.

Within the southern area, the marsh land is bordered for its entire length by the lowland terrace, which presents the same winding course, and rises to a height of from 10 to 15 feet. In some localities, at points nearer the terrace, this bog land is

above the reach of high tide, a fact which would indicate a present elevation of the coast. The fishermen assert emphatically that the Delaware shore is rising; and at Lewes, these assertions are authenticated. Boat-houses which were once at a convenient distance from the water have frequently been moved nearer, of necessity. An old yacht, said to have been wrecked twenty-five years ago, is now lying not less than 50 feet inland and 3 or 4 feet above mean tide.

While no attempt is here made to measure the rate of elevation, there is no doubt but that the fact of such an elevation can be established. The New Jersey coast and the shore of the southern Atlantic States show evidence of a slow subsidence; but these coast regions have not been covered by the sea since the later Tertiary, while the Delaware peninsula, totally submerged only as far back as the Post-Glacial, has not finished the slow operation of emergence from the sea.

ART. XI.—*Report of the Superintendent of the United States Coast and Geodetic Survey showing the progress of the work during the fiscal year ending with June*, 1883.*

ON December 1, 1833, Mr. F. R. Hassler, Superintendent of the Coast Survey, presented to the Secretary of the Treasury a letter reporting the progress made in the work of the survey of the coast.

Excepting a report (of 3 octavo pages) to the Secretary of the Treasury in November, 1817, also by Mr. Hassler, this was the *first* Coast Survey report, and for about ten years it was followed by similar reports consisting of a few octavo pages. In 1844, under the superintendence of Prof. A. D. Bache, these annual reports to Congress, which appeared as executive documents, began to grow, and in 1851 had attained to a size of 559 octavo pages. Beginning with 1852, however, the form was changed; the octavo form was abandoned, and in its stead came the quarto, so much better adapted to the presentation of maps and illustrations.

The report for 1852 may therefore be regarded as the beginning of a series of which the volume before us is the thirty-second.

The publication of these annual reports of progress has continued, sometimes with delay but without interruption, and the prompt issue of the present volume indicates that the delay in the publication of the later volumes is practically overcome.

* xxvi and 448 pp, 4to, with 50 maps, sketches and illustrations. Washington, 1884. Government Printing Office.

During the fiscal year 1882–3 the annual reports for 1878, 1879 and 1880 were printed and distributed, and "but for a contractor's failure to produce the sketches and illustrations in time" the 1881 report would have been found in the same category.

But the 1881 report was actually issued more than a year ago, shortly followed by that for 1882, and now the 1883 report has promptly followed.

That this volume should be a worthy successor in this long series we have a right to expect, and we are not disappointed. From the nature of the subjects treated in the scientific parts of these volumes it is but natural that some volumes would prove of more popular interest, or of interest to a larger class of readers than others. The appendices in the present volume, Nos. 12 and 14 *on refraction in connection with hypsometric measurements* and on *standard topographical drawings*, are likely to render this a volume for which there will be more than the usual demand.

The report before us departs but very little in its form, or general make-up, or class of topics treated, from its predecessors.

The general form, originally adopted in this series, has required and indeed has received very little modification during its 33 years of existence. Broadly stated, these reports present two classes of facts and for two classes of readers. The first may be called the *official* and the second the *scientific* report.

The *official* report presents brief statements of results obtained, then the same in greater detail; also, statements of when, where and by whom the work of the survey has been carried on, and an estimate for the use of Congress of the money necessary to carry on proposed work. This is followed by reports from the various divisions into which the office work is divided, giving statistics of the work done during the year. This official part may then be regarded as an exhibit of the machinery by which results are obtained, with figures showing the capacity of the machine.

The *scientific* part of the report is embodied in appendices prepared by specialists in the survey, who digest the raw material, deduce general laws or principles and point the way to improvements in methods and results. The volumes do not in form exactly conform to this. From a scientific point of view such an arrangement would doubtless be preferable, but whether expedient or not must be decided by the survey itself. Even as it is, the "make-up" of the volume is so well done that no one consulting it need lose time in finding what he seeks. The table of contents, list of appendices and their contents, list of sketches and illustrations, and the alphabetical index of 18 pages, furnish the needful guides for rapid consul-

tation. That this is Senate Ex. Doc. No. 29, 48th Congress, 1st Session, the bibliographer will not learn from the volume itself. This absence we pardon the more readily on account of the improved appearance of the title page. Still this useful piece of information might have been somewhere retained.

The report proper consists of 74 pages in two parts; the *first* of 11 pages, giving results in the most general terms and closing with *Estimates*, and the *second* of 63 pages giving in detail accounts of the work done in the 17 sections into which the territory of the United States (Alaska included) has been divided.

Appendices 1 to 5 inclusive, 46 pages, contain statistical information and reports from heads of various divisions, etc. While in general form these appendices are like their predecessors, we note some changes. There is a report to the Superintendent of the Assistant in charge of Office, to which report are appended reports from the Computing, Drawing, Engraving, Instrumental, Tidal and Miscellaneous divisions, and from the custodian of the Archives.

Great activity in hydrographic work is shown during this year, as appears from the report of the Hydrographic Inspector; 95 naval officers, and 21 of the 25 vessels being in service.

Appendices 6 to 19, pp. 121–488, constitute the scientific part of this report and cover a variety of subjects, such as Astronomy, Bibliography, Geodesy, Gravity, Magnetism, Tides, etc.

The bibliography, which is by Assistant Edward Goodfellow, and covers 15 pages, is entitled a "*Descriptive catalogue of publications relating to the Coast and Geodetic Survey and to standard measures.*"

This catalogue of the publications of the survey is classified under the several heads of Annual Reports, General Index of Scientific Papers, Lists of Tide Tables, of Coast Pilots, of Chart Catalogues, Notices to Mariners and Special publications. Although only a descriptive and not an analytical catalogue, the references in its tabular lists to the dates, forms and modes of publication are sufficiently explicit to enable any librarian to complete the classified list of Coast Survey publications which may form part of his catalogue.

Appendix No. 7 is an elaborate table of 100 pages, showing the depth of water which can be carried into various harbors of the United States and adjoining coasts. This is a practical rather than a scientific matter, and its value for the use of commerce and navigation is readily perceived.

In Appendix No. 8, Assistant Henry Mitchell presents in a very brief form, the condensed results of an elaborate and careful study of what he terms the *Estuary of the Delaware*, being

that part of the Delaware river between Philadelphia and a point 53 miles below. In this stretch of water, 734 lines of soundings have been run across the river, from which data the area of section and average depth have been calculated and tabulated. These results are presented in tables and in diagrams and strongly reinforce a conclusion based upon preliminary data and published in the C. & G. S. Report of 1879; this conclusion is that, in the language of the Superintendent, "*In the Estuary of the Delaware from League Island to the submerged delta, the mean depth is constant; the widths and sections vary with the square of the distance, and the retard of the tide can be exactly stated in terms of the mean depth and width.*"

Mathematically, then, these relations are expressed by equations of parabolas in which the constants have been empirically determined.

Let x be the distance of any section of the river from the Fort Mifflin section, down stream, measured along mid stream and in nautical miles; then we have

Mean depth in feet	$=18{\cdot}64$
Mean width of stream in feet	$=10{\cdot}1x^2+5100$; and
Mean area of section in sq. ft.	$=188x^2+95000$.

The curves resulting from observation agree well with the curves resulting from these equations, particularly the latter, in which the coefficient 188 results from multiplying the preceding coefficient 10·1 by the average depth 18·64 feet. This depth, 18·64, is the mean of all the soundings in the river for 46 miles below Fort Mifflin.

The expression for high water is stated to be

5·11 *distance* − 0·0018 *width* + 92 *minutes* where "*each term has its distinct physical meaning,*" but what that meaning is we are not told.

A sketch of the estuary accompanies this appendix.

Professor Wm. Ferrel, whose mathematical researches in practical directions have been so valuable, contributes two papers upon a topic peculiarly his own, viz: the tides. The first is a brief account of the results of the harmonic analysis of the tides at Sandy Hook, 1876–1881. It has special reference to determining the constants necessary to be used for this place in the tide-predicting machine.

Incidentally the mass of the moon is deduced from these 6 years' observations, and found to be between $\frac{1}{74}$ and $\frac{1}{77}$, the corresponding determination from the Penobscot Bay tides being $\frac{1}{85}$ and from the Boston tides $\frac{1}{75.1}$.

The *second* paper, however,—Description of a maxima and minima tide-predicting machine—is a much more important

paper. Besides it is self-contained and, therefore, does not require the examination of other papers to be understood.

After a brief introductory note alluding to the tide-predicting machine of Sir Wm. Thomson, first constructed about 1875 and the subsequent enlarged and improved one constructed under the direction of Mr. E. Roberts in 1879, Prof. Ferrel proceeds to describe and explain, both theoretically and practically the workings of the machine devised by him, and constructed at the Coast and Geodetic Survey Office under his direction, for predicting the *times and heights of high and low water* for any given station.

In Thomson's machine and its successor—now in successful operation for predicting tides on the coast of India the machine traces the tidal curve on a long strip of paper. From this strip of paper the times and heights are to be read off and tabulated in form for printing and publication. This machine, therefore, makes known the height of the tide for every instant.

In the machine now first constructed and described by Prof. Ferrel we obtain *not* a curve giving the height of the tide at all times; but for the particular times we desire, viz: at high water and at low water we obtain the times and heights. The machine, therefore, which gives these results is for distinction called a "*Maxima and minima tide-predicting machine.*"

It is of interest to note that the theory upon which the machine solves the tidal problem is more accurate than the usual mode of computing. In the words of the author:

"The formulæ used in the machine are those best adapted to obtain the results accurately by computation. This, however, involves so great an amount of labor that it has been necessary heretofore to use more simple formulæ, requiring much less labor in computation, but which give often only very rough approximations to the true results. These can now be pretty accurately obtained with scarcely any labor."

Against this greater theoretical accuracy must be set off the inaccuracies due to mechanical construction; but when this has been done the machine still shows results quite equal to the results obtained by direct computation even when tested by tides so different as those at Boston, San Diego and Tahiti.

In capacity for doing work the author estimates the machine to be equivalent "to 30 or 40 computers, if these were to take account of everything which the machine does."

According to this estimate we may say that if *one* computer could by the usual mode of computation make the tide-tables for the Atlantic sea-coast of the United States in *one* year *without* the machine, then *with* the machine he would in one year predict the Atlantic tides for the next 30 or 40 years.

When it is borne in mind that the constants for setting the

machine are to be computed beforehand for each station, each year of observations by itself according to the author's plan, and that to derive the constants from one year's observations will take an experienced computer several months, we see that the efficiency of the machine has been counted from where this long preliminary computation left off. Practically, therefore, its present efficiency is very materially less than 30 computers.

When once the tidal observations at a station have been completely put through the laborious harmonic analysis and the machine constants calculated, then it may be that the machine can predict for that station in one day as much as it would take a computer 30 or 40 days to do.

A comprehensive understanding of this valuable paper is only to be obtained from a careful study of the paper itself and of the five sketches with which it is illustrated.

We note that Plate III, the *front* view of the machine, is in the list of sketches called *back* view, while Plate IV the *back*, is called *front* view. This would have been obviated by printing legends on the plates themselves.

In appendix 11, Mr. C. A. Schott discusses the observations for the length of the Yolo base line. This base line, it will be remembered, is a very important primary one in the Sacramento Valley, California, and is the measured basis for the western end of the trans-continental system of triangulation. The apparatus, of an entirely new design, and the method of observing were fully described in the report of 1882. We now have the result; this result is that we have a measured base line about 11 statute miles in length, and the uncertainty in this measure is only about $\frac{8}{9}$ of an inch, or in meters the Yolo base line is

$$17\,486{\cdot}^{m}5119 \pm 9{\cdot}57^{mm}.$$

In length the whole line was measured twice, and a part of it three times, and this by a corps of the most qualified and experienced men in the survey. No known precaution for obtaining a measure of high precision was omitted, and the result obtained now shows a measure far surpassing in accuracy any previous measure by the survey, and, with a single exception, the most accurate base measure yet secured anywhere. Not the least satisfactory part of the whole matter is the clear summing up and presentation of results in print. The appendices in these reports from year to year show, in spite of good editing, marked differences in this respect.

In the 12th appendix, Asst. Schott discusses the third series of observations made, by Asst. Davidson and party in California, for determining the coefficient of refraction.

The difference of level of two stations, Mt. Diablo and Mar-

tinez East, was determined by spirit leveling to be 1116·09 meters (3661·7 feet). This difference of level was also further determined from hourly readings of the barometer for about 40 days, and also from hourly observations of reciprocal zenith distances during the same time, whenever the weather permitted. The results by the three methods are compared and some general principles deduced.

In the 13th appendix, also prepared by Mr. Schott, we have the first general account, with results from magnetic observations, of the U. S. International Polar Station at Ooglaamie near Point Barrow, Alaska. Mr. Schott makes very clear at the outset, the nature and extent of the coöperation which the survey was able to give. This coöperation related solely to terrestrial magnetism, and this appendix is entirely devoted to a discussion of the results obtained. Owing to the want of trained observers and the necessary instruments, whose production requires time, the coöperation the first year was "incidental" rather than complete. The second year additional instruments and an additional observer rendered the coöperation much more complete and satisfactory.

Regular magnetic observations began December 1, 1881, and continued hourly, with two short interruptions, till August 27, 1883, giving a series of about 21 months. The observations during the year 1881–2 consisted of hourly observations of the declinometer and dip circle (with needle weighted), and the term day observations. During the year 1882–3, differential magnetometers were in place and gave hourly readings of declination, horizontal force and vertical force. The absolute measures of the elements were continued through this second year.

The estimate of Mr. Schott, who has gone over these records with laborious fidelity is that the "*records and results herewith presented are the outcome of faithful labor, and are believed to be an acceptable contribution to our knowledge of magnetism in high latitudes, and it is thought that in the second year, at least, these records will prove to be a valuable part of the material accumulated by the several expeditions.*" We hasten to add to this that Mr. Schott's experience, skill and diligence in the discussion of magnetic observations are shown by the long series of papers on this subject from his pen during the past thirty years, and if, therefore, he has succeeded in extracting a "contribution to our knowledge" from a series of observations that reveal serious self-contradictions, important omissions and defects which nothing but patient ingenuity and skill can harmonize even roughly, he deserves our hearty thanks. No one experienced in the study of terrestrial magnetism is ignorant of the fact that his own earlier observations were poor, and

improved with experience. We may, therefore, judge the character of these observations when we know that not a single member of the party at Point Barrow had ever made the simplest determination of a magnetic element when assigned to this work. That the observers obeyed orders and did the best they could is not to be doubted for a moment. Nor is it any less certain that they were all inexperienced in magnetic work, and that therefore their observations are bad, many of them very bad. The extraordinary torsion correction, for the proper determination of which no proper data were furnished and which amount to $5\frac{1}{2}°$! in some cases, will illustrate the difficulties confronting the author beginning his reductions and computations.

The finally adopted values of the magnetic elements at the station from all the observations available, are,

Declination	35° 37′·2 E.	(Epoch Mar. 1, 1883).
Dip	81° 23′·4	(Epoch October, 1882).
Hor. force (Br. units)	1·939	(Epoch October, 1882).

The results for absolute declination as derived from the computations by the observers themselves varied from $35\frac{1}{4}°$ to $41\frac{1}{2}°$; but for the greater part the mean declination obtained was about $41\frac{1}{4}°$ E. The value which from a comparison of all the conflicting data Mr. Schott has been obliged to adopt is, as above given, some $5\frac{1}{2}$ degrees less than this.

The report of Asst. Edwin Hergesheimer on standard topographical drawings consists of two pages of letterpress and 16 topographical drawings which are designed and executed as models for the use and guidance of those engaged in topography. The author himself says they are designed as "guides for inking the original plane table sheets of the Coast and Geodetic Survey," in other words as model sheets. As evidence that they satisfy this requirement it may be said that already two large technical schools in this country have ordered a large number of copies of this report for use as a text-book in topography. Excellent as are these drawings, even after their transfer to the stone, the impressions from the original copper plate are yet more satisfactory, while the original drawings of Mr. Hergesheimer represent the highest attainments thus far achieved in topographical representation.

Appendices 15 and 16 contain brief reports on the Transit of Mercury in 1881 and of Venus in 1882, while appendix 17 is a brief report by E. D. Preston, consisting of a statement of the work done by him in connection with the observations of the solar eclipse of May, 1883.

Appendix 18 is a new, revised and enlarged edition of Prof. David on's catalogue of time and circumpolar stars published

in 1874. The number of stars in the old catalogue was 983, while in this one there are 1278, and the epoch is 1885·0.

The final appendix, No. 19, is on gravity determinations at Alleghany, Ebensburgh and York, Pennsylvania, in 1879 and 1880, by Asst. C. S. Peirce. From notes in the midst of the paper we learn that this is only a part of a separately printed paper on the same subject in which the details are given. For an understanding of the method of obtaining results reference must be had to previous publications by the same author.

The resulting length of the seconds-pendulum, expressed in meters, at the three stations of which the paper treats are as follows:

Alleghany	0^{m}·993 0308
Ebensburgh	0 ·993 0244
York	0 ·993 053

the latter determination being less strong than the two preceding.

We have looked with interest to these results to learn whether a station, as Ebensburgh on the crest of a mountain chain and more than 2000 feet above the sea-level, would reveal an excess or deficiency of gravity, but upon this matter the author makes no statement.

The sketches at the close of the volume revealing the progress of the survey during the year are prepared from plates which have seen service many years, and this fact appears in a variety of ways, particularly in the titles of which the later are much improved in appearance over the earlier ones.

A general comparison of this report with those preceding it by a few years indicates an improvement in arrangement, and a closer adaptation to the present conditions of the work. Special prominence is given to discoveries and developments having an immediate bearing on the interests of commerce and navigation. In the scientific value and practical bearing of the papers published in the Appendices, the Report compares well with its predecessors.

ART. XII.—*On Combinations of Silver Chloride, Bromide and Iodide with Coloring Matters;* by M. CAREY LEA, Philadelphia.

WHILE studying these silver salts in May last, I found that they had the remarkable property of entering into chemical combination with many coloring matters very much in the same way that alumina does, though not to the same extent, forming what may be called lakes. It is only necessary to bring freshly precipitated and still moist silver salt into contact with the coloring matter, or to make the precipitation in the presence of the coloring matter if the latter is not precipitated by silver nitrate, when the combination takes place and the coloring matter cannot be washed out by any amount of washing. A prolonged absence following immediately after has prevented the continuation of the investigation. It is still incomplete and the leading facts only are mentioned here to take date.

Not all coloring matters are capable of uniting with the silver salts, but the number of those that do so unite is considerable. What is curious and tends to show that the combination is intimate is that the color assumed by the silver salt is not always that of the dye, but may differ from it considerably. Also the three silver salts may be differently colored by one and the same coloring matter.

More frequently, however, coloring matters impart their own shade or something approaching to it; thus, silver bromide precipitated in presence of excess of silver nitrate takes from aniline purple a strong purple color; from cardinal red a bright flesh or salmon color; from napthaline yellow a light yellow color; from eosin a brilliant pinkish or salmon, and so on.

Different specimens of the same color gave sometimes quite different results; thus silver bromide precipitated in presence of silver nitrate was dyed by one specimen of methyl green to a bluish green. Another specimen of the same color obtained from a different source colored the same silver salt a deep purplish shade. Silver iodide showed the same difference.

Sixteen years ago, I proposed to color or stain the photographic film in order to modify its behavior towards light; principally to prevent blurring or irradiation.*

Of many coloring matters then tried, the best proved to be litmus colored red by acetic acid. This was very effectual for the purpose and was long used by others as well as myself. So far as I have been able to ascertain, it was the first suggestion made of this mode of acting on the sensitive plate. Since

* British Journal of Photography, 1868, 210, 506; 1870, 145, etc.

then staining the film has been found to have other applications and many others have experimented in this direction, in most cases with a view to alter its sensitiveness relatively to the different colors of the spectrum. Major Waterhouse was, I believe, the first to recognize this effect.

Dr. John W. Draper appears to have first advanced the view that substances sensitive to light are affected by the rays which they absorb. There is much to support this theory, although it cannot be considered as definitely established.

Some years since Dr. H. W. Vogel expressed the opinion that when sensitive films were washed over with solutions of coloring matters, the films gained sensitiveness to those rays of the spectrum which the coloring matters absorb, with this condition, that the coloring matter in question must be capable of combining with Cl, Br, or I, as the case might be. My own results were different. I found that the action of the rays was profoundly modified by coloring the film, but the result did not seem to conform to any law, and as often contradicted Vogel's view as agreed with it.

Vogel's theory necessitates the assumption that the color imparted to the silver salt is identical with that of the dye used, and as has been shown above, that by no means follows. He supposed that the capacity of any given color to influence the silver salt depended upon its tendency to combine with Cl, Br, and I, whereas, as we have above seen, its action most probably depends upon its ability or inability to combine with the silver haloid.

But the principal source of error has arisen from the fact that when the film is stained the effect is necessarily a confused one. Besides any influence that may be exerted on the particles of silver haloid, these particles are virtually behind a color screen, which must materially modify the nature of the light that reaches them, and the final effect must necessarily be a combination from two distinct causes. Moreover, the color in the film tends to arrest precisely those rays to which it is proposed to render the silver salt more sensitive; a consideration of the utmost importance, for the one action tends to counteract the other, and thus leads to inextricable confusion. From a system of experiments so faulty no just conclusions could be drawn.

Whether with these sources of error eliminated Draper's view, that a sensitive substance is influenced by those rays which it absorbs, can be applied to these new combinations which I have here described, is a matter on which I am not prepared to express an opinion, having been, much to my regret, unable as yet to examine the question. It seems *à priori* probable, but in that case it is important to observe that

the effect will depend firstly, upon the capacity of the dye to combine with the silver haloid; and secondly, not on the proper color of the dye isolated, but on the color that the silver haloid acquires under its action, which as we have already seen may be something quite different from the color of the original dye.

I have observed that the silver salts are greatly changed by conversion into lakes, even when the color imparted is but faint. They become in some cases much more finely divided and remain long in suspension. In one case at least, a great increase of sensitiveness to light for development was observed. Later I shall hope to give more definite details on these points.

In the above facts will doubtless be found an explanation of many of the anomalies in the behavior of colored films which have caused such wide differences of opinion. And the new modes of operating deducible from the reactions here described will, I think, be found of extended utility. Silver salts can be dyed first and emulsified afterwards, and the ability to color the sensitive salt to any shade with certainty and without introducing a counteracting influence into the film gives a new power in photochemistry.

ART. XIII.—*On the present state of our knowledge of Refraction Equivalents;* by Dr. J. H. GLADSTONE, F.R.S.

IT is well known that every substance has its refractive index, but this varies with change of temperature or pressure, and by the passage from the fluid to the gaseous or solid condition.

The specific refraction of a substance, that is the refractive index minus unity divided by the density, does not vary under the above circumstances, or varies but little.

The specific refraction multiplied by the atomic weight is termed the Refraction Equivalent of a body; and it is a law deduced from a very large number of observations by several experimenters that the refraction equivalent of a compound body is the sum of the refraction equivalents of its constituents.

If this law held true absolutely (like the analogous law in regard to atomic weights), we could draw up a table of the refraction equivalent of each element, and show some curious and suggestive relations between them; we could calculate beforehand the refraction of every compound body if we only knew its specific gravity; and there the value of the investigation would probably cease.

But the law does not hold good in every instance. The refraction equivalents of the elements vary with a change of valency, or mode of combination, and thus the study of them is capable of affording valuable insight into the chemical structure of compound bodies.

This fact has been recognized for several years, but the researches of Brühl, published about three years ago, drew far more attention to it, especially as he showed that wherever a carbon atom is in that condition which chemists often express as "double linked" its refraction equivalent is no longer 5·0, but 6·1, and that oxygen in organic compounds has two equivalents according to its manner of linking. During the past twelve-month papers have appeared on this subject, not only in England, but in other countries, especially by Nasini of Rome, Kanonnikow of the Kasan University, G. Quincke, and Bleekrode of the Hague.

These recent papers have not only added largely to our data, but they have had an important bearing on several branches of the subject; for instance:—

1st. They have thrown fresh light on the physical questions at the basis of the enquiry. Thus Bleekrode, in a communication made to the Royal Society of London, has examined the specific refraction of eleven liquified gases, and has shown that it is the same for the liquid and the gaseous conditions, at least within limits that may probably be attributed to the errors incidental to so difficult an enquiry. Kanonnikow has given additional proofs that the specific refraction of a salt or other solid body is not altered by solution. It has been shown more fully than before that the specific refraction is a constant unaffected by change of volume due to pressure. There is also an accumulated mass of evidence that this same property is not changed by ordinary chemical combination.

2d. These investigations have rendered the determinations of the refraction equivalents more exact. Thus Kanonnikow has examined salts of the metals contained in the two first columns of Mendelejeff's table, with results not differing widely from those previously obtained by the author; and Nasini has determined two values for sulphur. From these and other recent researches the author has been induced to revise the table printed by him in the Philosophical Transactions of 1869 with the result given below.*

3d. Deductions have been drawn as to the chemical constitution of various organic bodies. Some of these are at present the subject of discussions by Flavitzky and others in various

* Since the paper was read at Montreal some of the atomic weights have been advised in accordance with the recent determinations of Professor Clarke and others.

continental journals. As the last instance of such deduction the author had examined the optical properties of pentine and isoprene, C_5H_8, just described by Tilden, and had come to the conclusion that they differ constitutionally from the terpenes or citrenes, $C_{10}H_{16}$, and have no less than four of the carbons double linked: they must therefore be expressed by a chain formula like pentane, C_5H_{12}, and amylene C_5H_{10}.

Element.	Atomic weight.	Refraction Equivalent.
Aluminium,	27	7·7
Antimony,	120·2	24·1
Arsenic,	75	15·4
Barium,	137	15·8
Beryllium,	9·1	5·0
Bismuth.	208	38·2
Boron in borates,	11	about 4
Bromine,	80	15·3
Cadmium,	112	13·1
Cæsium,	133	19·2
Calcium,	40	10·0
Carbon,	12	5·0
Carbon, double linked,	12	6·1
Cerium,	141	20·0
Chlorine,	35·5	9·9
Chromium,	52·1	15·3
Chromium in chromates,	52·1	about 22
Cobalt,	57	10·4
Copper,	63·3	11·5
Didymium,	145	23·1
Fluorine,	19	1·6?
Gold.	196·6	23·1
Hydrogen,	1	1·3
Iodine,	126·8	24·5
Iron, bivalent,	56	11·6
Iron, trivalent,	56	19·4
Lanthanum,	139	23·0
Lead,	207	24·3
Lithium,	7	3·5
Magnesium,	24	6·7
Manganese,	54	11·5
Manganese in permanganates,	54	about 25
Mercury,	200	19·4?
Nickel,	58	9·9
Nitrogen,	14	4·1
Nitrogen in bases, oxides, &c.	14	5·1
Oxygen, single bonds,	16	2·8
Oxygen, double bonds,	16	2·4
Palladium,	106	21·6?
Phosphorus,	31	18·3
Platinum,	195	24·7
Potassium,	39·1	7·85
Rhodium,	104·3	23·6?
Rubidium,	85·5	12·1
Selenium,	79	30·5
Silicium,	28·2	7·4
Silicium in silicic acid,	28·2	about 6
Silver,	108	13·2
Sodium,	23	4·4
Strontium,	87·5	13·0
Sulphur,	32	16·0
Sulphur, single bonds,	32	14·1
Thallium,	204·2	20·4
Tin, bivalent,	118	27·0?
Tin, quadrivalent,	118	18·6?
Titanium,	48	24·6
Uranium,	239	19·5
Vanadium,	51·3	24·8?
Zinc,	65	9·8
Zirconium,	89·6	21·2

Art. XIV.—*Decay of Quartzyte: Pseudo-breccia;* by James D. Dana.

In the paper on the "Decay of Quartzyte" published in the last volume of this Journal, I briefly mentioned the occurrence of druses of quartz crystals coating the surfaces of cavities in the iron-colored bands and covering also the limonite in the larger cavities. I said nothing on the origin of these evidently recent quartz deposits. I add here the only fact as yet obtained that seems to bear on the subject. The mass of quartzyte shows by

the occurrence in it of a few large ragged cavities, and also of many minute holes near and also away from the colored bands, visible under a common lens, but better in thin sections under a compound microscope, that the rock probably contained grains and larger pieces of feldspar. If so, alkaline silicated solutions (derived from the action of carbonated waters on the feldspar) may have been the source of the crystals. So much of the quartzyte of Berkshire is of this feldspathic character that the supposition is reasonable; but more facts are needed to sustain it. The feldspar (orthoclase) in the quartzyte of Cheshire and Washington (referred to in the former article) occurs both in fine grains and large.

In the making of the pseudo-breccia the iron-colored bands are largely, as I stated, only stained quartzyte, the staining due to the spreading of the oxide either side of a crack. This is well seen in thin sections. The crack is generally a result of the wedging action consequent on the deposition of the iron oxide within an incipient crack or opening. This wedging action, in most of the pseudo-breccia specimens I have collected, has been small, the pieces lying very nearly in place, notwithstanding the appearance of large displacement occasioned by the spread of the oxide. But in one of the specimens it is relatively large, some of the intervals between the pieces being a sixteenth of an inch wide. Where the width is greater than this, pieces of the quarzyte occur within the band of oxide that are results of the septation process. In the specimen here referred to the oxide is oxide of manganese. In the wider openings it makes mammillary crusts over the opposite surface of the fissures, but extends across the fissure in some parts. There are no quartz incrustations. The opening of cracks by a wedging action from the slow depositing of a crystallizing mineral substance is finely illustrated in the well-known split and enlarged heads and stems of crinoids, from the Sub-carboniferous limestones of Indiana, Illinois, etc., in which the introduced mineral is quartz. The specimen here referred to (three-fourths of a pound in weight) is one-sixth manganese oxide, and consequently the oxide must have come from an external source. It was obtained at one of the Limonite ore-beds near the eastern foot of Mt. Washington, where manganese oxide was the chief product; and it was originally a mass of quartzyte in the drift; there is no quartzyte in place in the vicinity. It contains some scales of a silvery muscovite.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Viscosity of gases.*—The leading article in the Annalen der Physik und Chemie, No. 11, 1884, is upon the validity of Maxwell's formula for viscosity. The author, Hr. Otto Schumann, sums up the results of his late investigation as follows:

(1) Maxwell's formula gives under certain conditions, and at higher temperatures, discrepancies which cannot be accounted for by faults of observation.

(2) By means of a coëfficient of correction Maxwell's formula can be made to give at ordinary temperatures results which agree well with the transpiration method.

(3) The transpiration method gives, on account of absorption, too large values for the viscosity of gases at higher temperatures. The results for steam are too small.

(4) The dependence of the viscosity upon the temperature increases with the same.

(5) The coëfficients of viscosity of all vapors investigated by the author have approximately the same temperature function.

(6) Puluj's relation between wave-lengths and index of refraction increases for the vapors of homologous ethers with the corresponding temperatures.—*Ann. der Physik und Chemie*, No. 11, 1884, pp. 353–403. J. T.

2. *Distribution of electric lighting over great distances.*—At the late International Electrical Exposition in Turin a committee reported upon this subject. M. Tresca gives the results reached by this committee in a communication to the French Academy. MM. Gaulard and Gibbs established between the station of Lanzo and intermediate stations a circuit, of which the total length, including the return circuit, was 80 kilometers. The wire was a chrome bronze 3·7 millimeters in diameter and uncovered. The current was an alternating one, produced by a Siemen's dynamo of 30 horse-power type, and the circuit was arranged so that the electrical energy could be utilized simultaneously by different methods of lighting in the exposition building, in the station at Turin, at Lanzo, or at intermediate stations. This utilization was accomplished by means of secondary generators of peculiar construction, which have been devised by MM. Gaulard and Gibbs.

On the 25th of last September there was in regular operation the following apparatus:

(1) At the exposition building 9 Bernstein lamps, 1 Soleil lamp, 1 Siemen's lamp, 9 Swan lamps and 5 other Bernstein lamps at a short distance. All of these lamps required different potentials.

(2) At the station of Turin-Lanzo, distant 10 kilometers, 34 Edison lamps of 16 candle power; 48 of 8 candle power, and one Siemen's arc light.

On the 29th of September the system included the station of Lanzo, distant 40 kilometers, where 24 Swan lamps, requiriug 100 volts, were maintained with perfect regularity. The number of transformations which diverse methods of lighting require can be effected by means of a system of secondary generators, which permit of the transmission of the electrical energy produced by alternating machines to a distance of at least 40 kilometers (about 24·2 miles).—*Comptes Rendus*, Oct. 6, 1884, p. 549. J. T.

3. *Heat and Electricity.*—F. KOHLRAUSCH has supported the theory that the phenomena of thermo-electricity result from the interchange of heat and electricity, the one carrying the other and interchanging energy. This theory has been called the *Mitführungstheorie.* Budde acknowledges that this theory explains many of the phenomena of thermo-electricity, and shows how the theory can explain the relation between the thermo-electric force and the difference of temperature of the thermo-electric junctions; but he discovers in the principles of thermo-dynamics objections to the conveyance theory. Kohlrausch does not urge any crucial experiment, for none exists which can test the truth of the contact theory or the conveyance theory.

Budde urges as an objection to the conveyance theory that in order to agree with the second law of thermo-dynamics it requires that the phenomenon of the thermo-electric chain should be expressed by means of a quadratic expression as a function of the temperature. Kohlrausch shows that Avenarius, Tait, Ammann and himself had been led to this quadratic expression. Budde does not believe that the results obtained by these investigators will be true at higher and lower temperatures. Kohlrausch in turn remarks that the metals when changed through great ranges of temperature cannot be considered as the same metals. The principal objection of Budde against the theory that electricity carries heat with it and that there is a constant interchange between electricity and heat in thermo-electric phenomena, lies in this, that one can perceive that there should be differences of distribution of heat when there are differences of heat level; but it is difficult to perceive that there should be an electrical current where there is no such difference. Kohlrausch remarks that in a pipe which conveys steam no difference of temperature is necessary in order that heat can be conveyed from one place to another by a difference of pressure. The conveyance of heat by electricity is conceivable, and this conveyance can be supposed to take place unequally in different substances. Kohlrausch believes that the *Mitführungstheorie* and the contact theory do not exclude each other, and that they may both be appealed to to explain thermo-electricity.—*Ann. der Physik und Chemie*, No. 11, 1884, pp. 477–481. J. T.

4. *Thermo-electric relations of amalgams.*—The peculiar character of mercury makes it very suitable for a standard of electrical resistance, and C. L. Weber urges its employment as a standard metal of reference in thermo-electricity instead of lead,

or pure silver. No thermo-electric current has been shown to exist between unequally heated portions of pure mercury. The author has investigated the thermo-electric relations between amalgams of mercury and other metals, and finds the following thermo-electric series for amalgams of 0·5 portions by weight of the following metals with 100 parts of mercury: tin, silver, lead, zinc, cadmium, bismuth.—*Ann. der Physik und Chemie*, No. 11, 1884, pp. 447–476. J. T.

5. *Elementary Text-book of Physics;* by Professors WILLIAM A. ANTHONY and CYRUS F. BRACKETT. Part I, 246 pp. 8vo. New York, 1884. (John Wiley & Sons.)—The appearance of a new text-book of Physics at this time is a matter of some importance. The rapid recent development of the subject in its various departments has served to make the older books antiquated and unsatisfactory, and many teachers will have been perplexed by the inability to find a work suited to the special needs of their instruction. To what extent the volume now offered will satisfy them will depend somewhat upon the character of the instruction they desire to give. Part I includes in Book I the Introduction and the development of the subject of Mechanics, embracing the mechanics of masses, universal gravitation, molecular mechanics and the mechanics of fluids. Book II is devoted to the subject of Heat. The remaining departments of Electricity and Magnetism, Acoustics and Optics are to follow in Part II. So far as can be judged from the portion of the work issued, it has some good features which will commend it to those interested, but it is not hard to find points to criticize. The subject matter is often difficult and the discussion of many topics is too general to be easily grasped by a beginner; more difficult, in fact, than is entirely consistent with the size and apparent object of the book. The learner is told that only simple mathematics are required, and yet he is soon introduced to the differential coefficient, and expected to understand the idea of summation. The nature of heat is regarded as satisfactorily explained by the statement that it is "a form of energy," and yet nothing is given in the earlier part of the volume from which the student can learn what the term energy embraces, or what the different forms of energy are, nor is the principle of the conservation of energy discussed. Certainly an elementary text-book which does not at the outset explain the fundamental principle of modern physics is very incomplete.

6. *Indexes to Chemical Literature.* — The Committee on Indexing Chemical Literature, consisting of Professors H. Carrington Bolton (Chairman), Ira Remsen, F. W. Clarke, Albert R. Leeds, Alexis A. Julien, presented a report at the last meeting of the American Association for the Advancement of Science. This report gives a list of indexes already published, with the name of the compiler and the place of publication. The list includes indexes to the literature of the following subjects: Uranium, manganese, titanium, vanadium, ozone (1875–1879 and 1879–1883),

peroxide of hydrogen (1818–1878), electrolysis (1784–1880), speed of chemical reactions, starch sugar, peroxide of hydrogen, dictionary of the action of heat upon certain metallic salts including an index to the principal literature upon the subject.

The committee also announces that indexes have been offered, or are in progress of preparation, by different gentlemen, to the literature of the following subjects: carbon monoxide, meteorites, arsenic, explosives, phosphorus, uranium (a second index).

In conclusion, the committee announces that, in consequence of their representations, the Smithsonian Institution has consented to publish Indexes to Chemical Literature which shall be endorsed by this committee. The Smithsonian places a limit to the number of pages which will be printed per annum, but the limit is a generous one. By thus securing the assistance of the Smithsonian Institution, chemists are assured of a reliable and authoritative channel of publication, together with a wide circulation, and the plan of coöperative indexing will undoubtedly receive a great stimulus. It is also stated that a limited number of the indexes published by the New York Academy of Sciences can be had by addressing the Chairman of the Publication Committee of the Academy, Professor D. S. Martin, 236 West 4th street, New York City.

II. Geology and Mineralogy.

1. *Geology of the Scottish Highlands.*—The important paper of Prof. Archibald Geikie, Director of the Geological Survey of Great Britain, reprinted from Nature, of Nov. 13, on pages 10 to 15 of this number is followed by a special report on the *Geology of the Northwest of Sunderland* by the geologists of the Survey whose work called forth that paper, Messrs. B. N. Peach and John Horne, the former in charge of the investigation. The results, besides settling a question in Scottish geology that has been long under discussion, illustrate a principle in geological dynamics, that of lateral-thrust in great displacements, which is of the highest importance. We cite the stratigraphical section of the report, with a few accompanying paragraphs, referring to the original article in Nature for the rest of the details.

"As the observer passes eastward along the magnificent quartzite sections on Crag Dionard and Conamheall, south of Loch Eriboll, he cannot fail to note the numerous flexures of the strata, and especially the peculiar type of their sharp anticlinal folds. As a rule, the eastern limb of each of these folds dips at a gentle angle to the southeast, while the west limb is highly inclined, vertical, even inverted, or sometimes broken by a reversed fault, the effect of which is to bring lower over higher beds. These reversed faults (*t t t* in Section) become more numerous eastward. They are admirably displayed both in ground-plan and dip-section on the shore north of Heilim, where they repeat the various zones ranging from the "pipe-rock" to the Eilan Dubh

limestone (Group II.). The strike of the reversed faults ranges on the whole with that of the strata traversed, and their hade is inclined at a higher angle than the dip of the latter, the difference generally amounting to about 10°. Inland from the coast-section, north of Heilim, to the base of Ben Arnaboll, the zones just mentioned are constantly repeated by a complicated system of reversed faults and folds, the general inclination of the strata being toward the southeast. As that hill is approached, the displacement produced by these faults increases in amount; hence the observer meets with beds occupying a lower geological horizon the farther east he travels. At length this intricate system of faults and folds culminates in a great dislocation which, for convenience of description, and to distinguish it from the ordinary reversed faults, may be termed a *thrust-plane*. By means of it a great mass of coarsely crystalline gneiss with pegmatite-veins, in places upward of 400 feet thick, is placed above the Silurian rocks (see Section). A careful examination of the mass which caps Ben Arnaboll clearly proves that *it rests transgressively on all the zones of the Silurian rocks, from the lower zone of the quartzite (false bedded grits) up to the limestone which overlies the Serpulite-grit.* Owing partly to its low hade and partly to subsequent folding, the outcrop of this thrust-plane resembles that of an ordinary overlying formation cut into a sinuous line by denudation. It is admirably seen in dip-section on the east and north slopes of Ben Arnaboll, whence it can be followed round the west face of the hill, descending into the

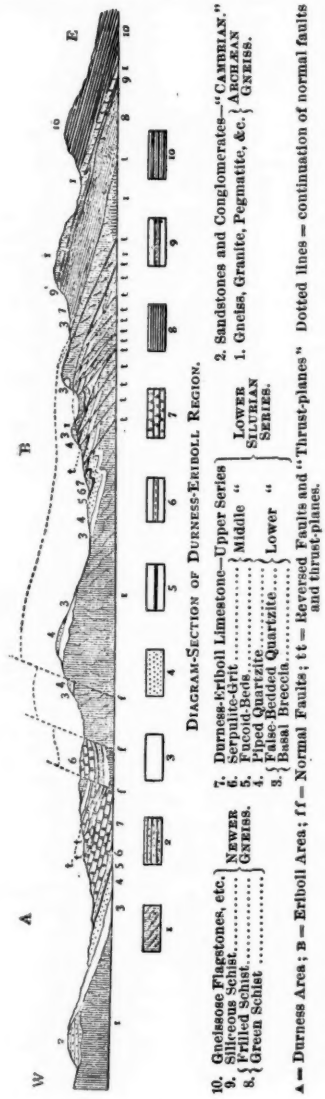


Diagram-Section of Durness-Eriboll Region.

A = Durness Area; B = Eriboll Area; ff = Normal Faults and "Thrust-planes" Dotted lines = continuation of normal faults and thrust-planes.

valley on the west, then bending back on itself, winding round the north slope of Druim Tungi, and entering Loch Eriboll in Heilim Bay. It reappears at the base of Crag-na-Faolinn, and has been traced still farther to the south, while northward it can be followed to the Whitten Head, at the mouth of Loch Eriboll.

That the gneiss thus brought up on Ben Arnaboll and elsewhere is in reality the Archæan gneiss is evident, for two reasons. First, its lithological characters agree with those of the typical Archæan area to the west, save in certain cases where the original features have been effaced by the crushing to be afterwards described. Near the thrust-plane, this effacement is complete, but in the heart of the mass the normal characters of the Archæan rocks, including in some instances their characteristic northwest strike, are retained. The rocks consist of coarsely crystalline hornblendic gneiss and pink granitoid gneiss, with lenticular veins of hornblende-rock and kernels of cleavable hornblende, while massive veins of pink pegmatite are well developed. The soft greenish mineral (agalmatolite?) already mentioned as characteristic of the gneiss, where now or lately covered with quartzite, occurs here in the pegmatites, and veins of epidosite are abundant. Second, at various localities the brecciated conglomerate and false-bedded quartzite at the base of the Silurian strata are found resting on these crystalline rocks. Further, the unconformable junction can on one line be traced continuously for more than a mile. There can be no doubt, therefore, that this mass is really a fragment of the old platform of Archæan rocks on which the Silurian strata were deposited.

But all these evidences of displacement are merely the precursors of a still more powerful thrust-plane, which has been traced continuously from the shore east of Whitten Head to the crest of Crag-na-Faolinn, and at intervals for many miles to the southward into the Assynt country. . . . .

One final feature of the Durness and Eriboll area remains to be noticed. The geological structure of this region has been further complicated by the subsequent folding of the strata, and by a double system of normal faults (*ff* in Section) which affect the strata and thrust-planes alike. One set of normal faults trends north-northeast and south-southwest, while another, which appears to be newer, trends more or less at right angles to these. By these two systems of later dislocations, the thrust-planes with their low hade have been intersected and shifted precisely as if they had been ordinary boundary-planes between two geological formations. Much of the difficulty, indeed, which has been from the first experienced in unraveling the complicated structure of this region may be traced to the effect of the intricate network of reversed and normal faulting. The very preservation of the Durness Basin is due to two normal step-faults, one of which lets down the quartzites more than 1,200 feet, while the other brings the whole Silurian Basin down to the sea-level."

2. *On a Chart of the ancient drift and glaciers of the northern Swiss Alps and Mt. Blanc Chain;* by M. ALPHONSE FAVRE (Geneva Archives des Sci., for Nov. 15).—Professor Favre states that this chart, prepared by him, shows by means of colors, the outlines of the névé and the true glacier of seven old glacier basins—those of the Rhine, the Linth, the Reuss, the Aar, the Rhone, the Arve, and the Isère, besides the névé and glaciers of the Jura and the outlines also of the modern glaciers. The author uses the positions of glacial scratches and of isolated bowlders, as well as moraines, for fixing the outlines of the old glaciers; and he opens with a remark on the good effect of the "Appel aux Suisses" by Messrs. Studer and Soret, and himself, made in 1867, in behalf of the protection of the more remarkable bowlders. He alludes to the barrier made by the terminal moraine between the extremities of the lateral moraines, and the effect in making lakes, some of which were great lakes in the era of the flood from the melting glacier. This was the case below Soleure, where the waters of the Aar were stopped by four great Valaisan moraines, and made a lake over 60 miles long. He points out how the map may be used for deducing the thickness and pitch of the glacier along the several valleys, and illustrates it by examples from the old glaciers of the Aar and Reuss.

The following table contains the heights, thickness, and other facts connected with the glacier of the Aar, at the Ewig Schneehorn, on the left bank of the glacier of the Lauteraar, where the glacier's height was 3000 meters; at Juchliberg, at the extremity of the left bank of the same glacier; at the Stampfhorn, below the Ritzlihorn on the east side; at the Brienzberg, south of the extremity of Lake Brienz; near Wimmis, where the glacier of the Simme encountered the glacier of the Aar; and at Gurnigel, 10 miles below Wimmis. The heights and distances are in meters; and in columns 4, 5 and 6 the numbers have reference to the interval between the consecutive localities.

	Upper glac. level.	Level of valley.	Thickness of glacier.	Distance.	Descent.	Surf. pitch for 1000 m.
1. E. Schneehorn,	3,000	2,747	263	11,000	500	45
2. Juchliberg,	2,500	1,874	626	5,500	250	45
3. Stampfhorn,	2,250	1,363	887	24,000	750	31
4. Brienzerberg	1,500	570	930	32,000	150	5
5. Wimmis	1,350	634	716	16,000	30	2
6. Gurnigel	1,320	597	723			

In the valley of the Grimsel the thickness of the glacier was accordingly 626 meters; and in that of the Hasli, 887 meters; and at the Brienzerberg, 930 meters, not counting the depth of the lake. The glacier of the Simme, which had near Erlenbach a height of 1350 m. above the sea, joined that of the Aar 7000 m. below, near Wimmis, giving both for some distance the same level, 1350 m.

A similar table is given for the glacier of the valley of the Reuss, which commenced at the highest point of Saint Gothard, as follows:

	Upper glac. level.	Level of valley.	Thickness of glacier.	Distance.	Descent.	Surf. pitch for 1000 m.
1. Wyttenw. Stock	3,084	2,190	894	45,000	1,724	38
2. Eggberg	1,360	437	923	13,000	0	0
3. Gotthardli	1,360	437	923	7,000	280	40
4. Rossberg	1,080	417	663	30,000	180	6
5. Lindenberg	900	409	491	26,000	100	4
6. Lägern	800	366	434	11,000	275	25
7. Reinerberg	525	330	195	6,000	25	4
8. Bottenberg	500	323	177			

Professor Favre remarks on the gentleness of the pitch over all the old Swiss glaciers. The glacier's height at Morcles below Saint Maurice, in Valais, was 1650 m., and at Chasseron on the Jura, near d'Yverdon, 1352 m., indicating a descent over the Swiss plain, of 298 m. in the 78 km. or 49 miles, between the two places, equivalent to 4 : 1000. At Chasseral, 57 km. to the northeast, the glacier's height was 1306 m., and at Mt. Salève, near Geneva, 92 km. from Chasseron, it was 1308 m.; and hence, over a distance of 149 km. across the plain, the surface was horizontal. The thickness of the glacier at Chasseron was 917 m. and at Chasseral about 871 m.

Professor Favre also speaks of the wide difference in some cases between the limits of the modern and the ancient hydrographic basins and course of drainage.

3. *Description of Geological Sections crossing New Hampshire and Vermont;* by Professor C. H. Hitchcock. 34 pp. 8vo, with two plates of geological sections. Concord, N. H., 1884.—These sections, by Professor Hitchcock, are the results of new field-work across the States of Vermont and New Hampshire since the New Hampshire Geological Report was published, and have much value. Professor Hitchcock here makes, as he had before announced, the Taconic slates of Emmons, south of Middlebury, to be Lower Silurian in age, and not older than the Trenton or the later part of the Trenton (the Hudson River or Lorraine division). The quartzyte is regarded as the Potsdam sandstone, and as overlying unconformably the Green Mountain rocks farther east.

The writer's opinion as to the existence of Archæan rocks in southern Vermont is mentioned, and he therefore here states that he has found evidence of the existence of isolated Archæan areas there, but that his examination of the beds of Mt. Mansfield lead him to doubt the Archæan age of a large part of the Green Mountains. J. D. D.

4. *The Till-ridge of New Haven, called Round Hill.*—Professor W. M. Davis, in his paper on Drumlins (this Journal, xxviii, 413, 1884), objects to the view that the material of Round Hill was deposited by waters descending a crevasse or knot of crevasses in the glacier (this Journal, xxvi, 358, 1883), on the ground of the absence of stratification. Bearing on this point I would recall the facts: that a broad trench or valley 40 to 60 feet deep (120 to 130 feet above the sea-level, and 170 to 180 below the summit of the hill), extends half-way around the hill, and is cut

out of the rocks to that depth; that from the bottom of the till of the ridge the pitch to tide-level, three-fourths of a mile off, is nearly 200 feet and from the top 300 feet. If the deposition took place after the subsidence that opened the Champlain period, a pitch of 200 feet in three-fourths of a mile, or 266 feet in a mile, would be reduced to 230 feet a mile. The difficulty in the explanation does not come from the absence of regular stratification, but from the existence of enough sand and clay in the hill-deposits to bind the stones together. Evidence of the violent action of the descending waters is plain enough about the hill in the valley described, and also in the bare rocks of the hills to the northeast, east and southeast of it, whose height is near that of the bottom of the till; for some reason they left the small area of the hill for the accumulation of the deposited material.

J. D. D.

5. *The Copper-bearing rocks of the Lake Superior region.* — In a notice of Professor Irving's report on these rocks in the last volume of this Journal (p. 462), the view of the author is stated as to their relations to the Annimikie group on the north shore of Lake Superior, and the Lake Superior sandstone, that (1) the Annimikie group is Huronian; (2) that the Keweenaw series is overlaid unconformably by the "Eastern Lake Superior sandstone;" (3) that the latter is probably Potsdam in age, as held by most geologists "from Owen to Rominger;" (4) that the unfossiliferous Keweenaw series may be older Cambrian.

We add here the views of Professor N. H. Winchell, Geologist of Minnesota, on the same points, as given in the 10th Report (1881), of the Geological Survey, and noticed in the Appendix of Professor Irving's Report. On the first of these points they are the same as above. On the second, or the unconformability of the copper-bearing rocks and the overlying series, there is agreement also; as stated on page 123, "at different places No. 1 [the light-colored sandstone seen in the Mississippi river bluffs and the bluffs of the St. Croix, containing Lingulæ and trilobites], and 2 [the horizontal sandstones of the south shore of Lake Superior, holding fucoids and Scolithus], have been seen unconformably overlying portions of No. 3 [the copper-bearing series or so-called Keweenaw formation]." On the third, Professor Winchell holds, from the fossils of the Eastern sandstone and the St. Croix beds, that the group probably belongs above the Potsdam sandstone, though Professor Hall refers the St. Croix fossils to that period. On the fourth point he makes the copper-bearing rocks equivalents of the Potsdam series.

The argument for the last-mentioned conclusion is largely lithological and therefore of little or no weight. That from the fossils in the slates and sandstones of St. Croix is indecisive, as remarked by Professor Irving, since the precise age of the fossils, whether Potsdam or later, is not certain. The Lingulæ of the sandstones of Tequamenon Bay, found by Rominger, which led him to refer those sandstones to the Potsdam, Professor Winchell

says make the Keweenaw series Potsdam, *if* the rocks are equivalents.

Mr. Wadsworth's discussion of the subject will be found in his memoir on the Iron and Copper Districts of Lake Superior, in vol. i, of the geological series of the Museum of comparative Zoölogy.

6. *The Geological and Natural History Survey of Minnesota.* The 12th Annual Report, for the year 1883, N. H. WINCHELL, State Geologist.—This Report contains a paper on the comparative strength of Minnesota and New England granites, by N. H. Winchell. The experiments were made on 2-inch cubes unpolished and appear to have been conducted with care. The average strength in pounds of 20 samples of Minnesota granites, crushed between steel plates, was found to be 104,800 pounds, or 26,200 per square inch of surface; when crushed between wooden cushions, 93,272 pounds, or 23,318 pounds per square inch. The tests were applied by Mr. James Cocroft, under the direction of Gen. Q. A. Gilmore.

The average obtained by Gen. Gilmore for 20 New England granites (in 1875) was 59,785 pounds, or 14,946 pounds per square inch.

The Minnesota granites are Archæan. How far this is the fact with those of New England is not known. An explanation of the differences might be obtained by an investigation into the relative porosity of the rocks, or their absorbent quality, the amount of mica, the presence of which fissile and feebly adherent mineral must always diminish strength, and other textural differences.

Following this report on granites the volume is occupied by a final report on the Crustacea of Minnesota, included in the orders Cladocera and Copepoda, by C. L. Herrick, assistant in zoology, which extends to 192 pages, contains a large number of new forms, and is illustrated by numerous plates. This extended memoir contains also "a synopsis of the described species in North America, and keys to the known species of the more important genera."

7. *Report of the Geological Survey of Ohio*, Vol. v. *Economic Geology;* EDWARD ORTON, State Geologist. 1124 pp. 8vo. Columbus, Ohio, 1884.—The various economical products from the rocks of Ohio are the subjects treated in this large volume, The stratigraphy and characteristics of the Coals, Iron Ores. Building Stones, Clays, and the methods of working and the industries connected therewith, are first reviewed at length, and then special reports added on the coal beds of different regions in Ohio. Besides Professor Orton, there are among the authors on these subjects, A. Roy, Inspector of Mines; N. W. Lord on the Iron manufacture, H. Newton on the manufacture of Coke; Edward Orton, Jr., on the clays and their industries; E. McMillin, on Gas Coals; and for the special reports on coal regions, A. A. Wright, C. N. Brown and E. Orton, Jr. There is also a

report on analyses of Coals, etc., by N. W. Lord; and another on the Glacial boundary in Ohio, by Prof. G. F. Wright. The volume is illustrated by many sections and maps. It is a valuable contribution to economical geological science.

8. *Contributions to the Tertiary Geology and Paleontology of the United States;* by ANGELO HEILPRIN, Prof. of Invert. Paleont. at, and Curator in charge of, the Acad. Nat. Sci., Philad. 118 pp. 8vo, with a colored geological map, showing the distribution of the several divisions of the Tertiary along the Atlantic coast and around the Gulf of Mexico.—This volume consists of the collected papers of Mr. Heilprin on the United States Tertiary, published by the Philadelphia Academy of Sciences, emended in some points, with new papers by him on the same general subject. The Tertiary paleontology of North America has needed a thorough revision in order to reconcile discrepancies between the results of different authors, correct references to localities, add further facts as to true stratigraphical order, and make full comparisons and all necessary identifications with the described species of the foreign Tertiary. Mr. Heilprin has been working in these directions, and has brought out a volume of great service to American geology, although much still remains to be done. His classification of the American marine Tertiary has already been given in this Journal, vol. xxiv, p. 228, 1882.

9. *Report PPP of the Geological Survey of Pennsylvania on Devonian Ceratiocaridæ*, by C. E. BEECHER, with 2 plates, and *on Carboniferous Eurypteridæ*, by JAMES HALL, with 6 plates.—Mr. Beecher describes new species of the genera *Echinocaris*, *Elymocaris* and *Tropidocaris*, the two latter genera being also new. The number of species of the group reached its maximum, according to the investigations thus far made, in the Chemung period. Prof. Hall describes the new species *Eurypterus Beecheri* and *E. stylus*.

10. *On the Structure and Affinities of the Receptaculidæ;* by Dr. G. J. HINDE. (Jour. Geol. Soc., 1884, 795.)—Dr. Hinde discusses with great fullness the structure and relations of these singular fossils, and concludes that they belong with the siliceous hexactinellid sponges. The body walls, he observes, are composed of spicules of the hexactinellid type, but modified by the development of regular rhomboidal or hexagonal plates in place of the head ray of the normal spicule. The family is represented in the Lower and Upper Silurian, sparingly in the Devonian, by a single doubtful species in the Carboniferous (described by F. Römer, from Silesia beds), and not in later rocks.

11. *Paleozoic Corals. Spitzenbergen fossils.*—G. Lindström has an "Index to generic names applied to the corals of the Paleozoic formations" in the Handlingar of the Swedish Royal Academy, vol. viii, No. 8, 1883.

The same volume contains a paper, by B. LUNDGREN on the Jurassic and Triassic fossils of Spitzbergen, collected by the Swedish Expedition of 1882; and also another, by TH. FUCHS, on

the Tertiary shells of Spitzbergen, from the same collections. The Tertiary shells include species (not satisfactorily determinable) of *Siliquaria*, *Pharella*, *Psammosolen* and *Venus* (*Circomphalus*), from the lower horizon near Kolbay, and *Cytherea* (Callista), and *Psammobia* from the upper, at Advent Bay, all unknown from the Arctic seas; also a *Thracia*, larger than the largest known. He observes that the species appear to be Miocene, or later rather than earlier; and that they do not sustain the view put forward by Gardener that the era of the Polar flora was Eocene instead of Miocene.

12. *Geology of Delaware.*—Professor F. D. CHESTER has a paper on the geology of the State of Delaware in the volume of the Proceedings of the Academy of Natural Sciences of Philadelphia for 1884, pp. 237–260.

13. *Lower Silurian age of the Peach Bottom roofing slates of York and Lancaster Counties, Pennsylvania.*—Dr. P. FRAZER has found fossil plants in these roofing slates and probable fragments, in Prof. James Hall's judgment, of graptolites, which point to the Hudson River or Quebec group age of the slates. The locality is on the Lower Susquehanna. The rocks are much tilted, and near the slates, and apparently above them occurs a quartz-slate, containing, like the Chikis quartzyte, intercalated hydromicaceous beds. They are among a series of chloritic schists.

14. *Paleozoic Arachnida.*—Mr. S. H. SCUDDER has published a revision of the subdivisions of fossil Arachnids in a paper in the Proceedings of the American Academy of Arts and Sciences, 1884, p. 13, in which he describes the new genera *Poliochera*, *Geraphrynus* and *Geralinura* for Mazon Creek species, and the new species *Anthracomartus pustulatus*, from the same locality; also *Anthracomartus trilobitus* from the sub-conglomerate coal-measures near Fayetteville, Arkansas.

15. *Professor E. D. Cope on fossil Vertebrates.*—Professor Cope has recently published the following papers:

The North American Batrachia, Amer. Nat., January, 1884.

Synopsis of the Species of the Oreodontidæ, Amer. Phil. Soc., January, 1884.

Structure of the skull in the Elasmobranch genus Didymodus, Amer. Phil. Soc., March, 1884.

The Creodonta, Amer. Nat., March, 1884.

The Tertiary Marsupialia, Amer. Nat., July, 1884.

The Extinct Mammalia of the Valley of Mexico, Amer. Phil. Soc., May, 1884.

The Mastodons of North America, Amer. Nat., May, 1884.

On the Structure of the feet in the extinct Artiodactyla of North America, Ibid., August, 1884.

Fifth contribution to the knowledge of the Fauna of the Permian formation of Texas and the Indian Territory, Amer. Phil. Soc., August, 1884.

16. *Note on Brazilian Minerals;* by ORVILLE A. DERBY.—In

an examination of the heavy sands accompanying the diamond at the newly discovered washings of Salobro or Canaviciras, near the mouth of the Jequelinhouha in southern Bahia, Professor Gorceix notes the absence of the oxides of titanium (rutile and octahedrite), of the hydrous phosphates of alumina and cerium, and of tourmaline, so characteristic of the diamond sands of Diamantina, Bagagens, and of the diamond region of Bahia. These sands are remarkable for containing monazite (the most abundant mineral after quartz), zircon, staurolite and corundum. The last two are noted for the first time among the minerals accompanying the diamond, and the last, corundum, for the first time definitely, in Brazil. Zircon, which is quite abundant, had been found rarely in the diamond sands of Bahia by Damour but never in those of Minas, while monazite had only been found rarely in a single locality in the Diamantina district.

Prof. Gorceix has also studied the *favas* (Lima beans) of the miners which are very characteristic of the diamond deposits of Diamantina and western Minas Geraes. These are discoid pebbles resembling in shape the seed from which they take their name, which decrepitate and give much water in the closed tube. Three series are recognized, two of which contain silica, alumina and a small proportion of phosphoric acid. The other more interesting series, of which the analysis has not yet been completed, contain titanic, phosphoric and vanadic acids, and the bases alumina, lime, iron, cerium, yttrium and didymium.

Christianite has been recognized by the same author in a decomposed pyroxenic rock from the head-waters of the Abaete, a western tributary of the upper San Francisco. The following analyses are given.

	No. 1.	No. 2.
SiO_2	47·5	46·9
Al_2O_3	20·6	21·5
Fe_2O_3	1·1	2·4
CaO	7·6	7·0
MgO	3·1	2·3
KO	4·4	4·6
NaO	0·8	1·6
HO_2	15·0	15·0
	100·1	101·3

—*Annals du Escola de Minas de Ouro Preto*, vol. iii.

17. *Spodumene crystals of gigantic size;* by WILLIAM P. BLAKE. (Communicated.)—The excavations upon the Etta tin mine in Pennington County, Dakota, have exposed numerous crystals of spodumene of unusually large dimensions. One crystal which extends horizontally parallel with a drift is thirty-six feet in length in a straight line, and is from one to three feet in thickness. It penetrates massive quartz and feldspar. The cleavage is smooth and straight, but the lateral and terminal planes are obscure. Crystals from five to twenty feet long are numerous and incline in all directions.

18. *Minerals from Kangerdluarsuk in Greenland.*—A paper recently published by Dr. Lorenzen, of Copenhagen, contains analyses and crystallographic notes on several minerals from Kangerdluarsuk in Greenland; an earlier paper by the same author has already been noticed (this Journal, xxv, 158). The name *Rinkite* is given to a mineral occurring in monoclinic crystals with arfvedsonite, ægirite, eudialyte, etc. Its color is yellowish brown when fresh, but the crystals are often altered so as to have an earthy structure and straw-yellow color. The hardness is 5, the specific gravity 3·46. The mean of several analyses yielded:

SiO_2	TiO_2	CeO DiO LaO	YO	FeO	CaO	NaO	Fl
29·08	13·36	21·25	0·92	0·44	23.26	8·98	5·82

$=103·11$, deduct $2·45$ O $= 100·66$

For this the formula proposed is $2\overset{II}{R}\overset{IV}{R}O_3 + NaFl$, although the correctness of the formula is not fully established. The name *Polylithionite* is given to a variety of lithia mica unusually rich in lithium. An analysis gave:

SiO_2	Al_2O_3	FeO	K_2O	Na_2O	Li_2O	Fl
59·25	12·57	0·93	5·37	7·03	9·04	7·32 =

102·11, deduct 3·08 O = 99·08

In optical relations this lithia mica stands very near zinnwaldite but is remarkable in containing more silica; this, the author states, cannot be due to impurity.

19. *Synopsis Mineralogica:* Systematische Uebersicht des Mineralreichs, entworfen von Dr. Albin Weisbach. Zweite Auflage, 87 pp. 8vo. Freiberg, 1884. (J. G. Engelhardt.)—This work contains a list of mineral species with a statement of their composition, and in most cases, the crystalline system to which they belong; the system of classification is rather artificial.

III. Botany and Zoology.

1. *Comparative Anatomy of the Phanerogams and Ferns;* by Dr. A. DeBary, Professor in the University of Strassburg. Translated and annotated by F. O. Bower, M.A., F.L.S., and D. H. Scott, M.A., Ph.D., F.L.S. (Clarendon Press, Oxford, 1884; pp. 659.)—DeBary's Vergleichende Anatomie has been in the hands of students since 1877. It has been everywhere recognized as the most exhaustive work on the subject hitherto published, but owing to this very fact and to its extremely technical character, we had almost despaired of seeing it in print in English. A manuscript translation prepared four years ago by Miss Mary Chapman, of Boston, has done good service in the Botanical Laboratory, in Cambridge, and has made known to not a few students, unfamiliar with German, the excellencies of DeBary's treatise. From what the present writer has seen of

the pleasure with which even a manuscript translation has been employed, he feels sure that the well printed and convenient translation which now comes to us will have many more appreciative students than the publishers have looked for.

Professor DeBary, in the preface, complains of the patchwork character of parts of the volume. He says that he had hardly finished one portion before those preceding it were out of date, and by remodelling, such portions necessarily lost something of their due proportion. But this is true of all encyclopedic treatises, and serves to indicate the magnitude of the work which DeBary has so well done.

The treatise is in two parts: (1), Forms of tissue; (2), Arrangement of the forms of tissue. The classification adopted in the first part is as follows: *Cellular tissue*, including epidermis, cork and parenchyma; (2), *Sclerenchyma*, comprising so-called "hard bast;" (3), *Secretory reservoirs*, or sacs; (4), *Tracheæ*, including Tracheids; (5), *Sieve-tubes;* (6), *Laticiferous tubes.* The account of intercellular spaces is placed properly in an appendix. Under ARRANGEMENT of these tissues, the author considers the occurrence of each kind in all classes of vascular plants, and regards the subject largely from the point of view of development.

The amount of material which is here brought together is absolutely surprising. The references are very copious and, as we have had occasion to note in a large number of cases, given without serious error in citation of volume or page. Although a part of the work of compilation must have been irksome in the extreme, it has been thoroughly and carefully done, and the treatise will long remain the most valuable digest of vegetable histology.

The translators have given us a good version. Here and there exception might be taken to their readings, but they are chiefly minor points which do not seriously impair the value of the hand-book. Almost unqualified commendation can be given to the translation for its fidelity, and, what is better, its clearness. The annotations add much to the value of the work and bring portions of the subject down to a recent date. Lastly, it should be said that the index is a marvel of completeness and accuracy, and places this encyclopedic treatise, which is crowded with details, perfectly at the service of the student. G. L. G.

2. *Living organisms in the air at high altitudes.*—A paper by M. E. DE FREUDERICH, on the number of living organisms in the air about the Swiss Alps, is published in the Geneva Archives des Sciences for November last (Nov. 15). He shows that the observations of Pasteur and Tyndall, as far as relating to this special point, are unsatisfactory because the germs are not destroyed at the temperature of ebullition, but require 110° C., and because the amount of air thus examined by the method they used was very small—hardly more than half a liter, he says, in Tyndall's experiments. Mr. Freuderich, in order to make his trials on a large volume of air, used first a hand air pump, which passed a

liter of air at each stroke of the piston, and in more recent trials, a portable steam pump which, under a pressure of two atmospheres, could move 2500 to 3000 liters an hour. The mean amount used was 150 liters an hour. The organisms were detained by a wad of spun glass in a glass tube, various precautions being used to insure accuracy. Each wad was afterward divided and each half put into a portion of beef bouillon for the development of any microbes present, in which process the bouillon became clouded. The method is one proposed by Dr. Miquel in the Annuaire de Montsouris for 1884. His trials in 1884 were made at the Theodule Pass, near Zermatt, 3322^{m} in elevation, above the limit of perpetual snow; on the Aletsch glacier, 2900^{m}; and in part at the summit of the Niesen, 2366^{m}, situated on the border of Lake Thun and surrounded by numerous villages.

On the Aletsch glacier, July 15–17, one trial of 500 liters of air, gave no organism; another of 800 liters, afforded one "maigre" *Bacillus subtilis;* one of 250 liters, a single organism of the family Torulaceæ; one of 50 liters, a single *Micrococcus*—about which there was some doubt. He thus obtained from 2000 liters of air, at a height of about 3000 meters, two Bacteria (a Bacillus and a Micrococcus) besides one of the Torulaceæ. In the second series of experiments, at the St. Theodule Pass, September 6, 7, one *Bacterium termo* was obtained from 3000 liters, or three cubic meters of air. In contrast with this extreme purity, the air at Berne gave him in one trial hundreds and even thousands to the cubic meter; and among the organisms in one case there were 444 microbes to the cubic meter, in another 250.

On the mountain of Niesen, in the last of July and first of August, rain, snow and a severe storm, complicated the trials. 600 liters of air, under these conditions, gave 4 Bacteria (all of one species); and in another trial, 4 Bacteria for 1725 liters. Adding the two, it makes 3 to 4 Bacteria to the cubic meter. With reference to the Bacteria being of a single species, the author states that on the plain in 1881, M. Miquel found 14 Bacilli to 79 of Micrococcus and 7 of Bacteria; and the author had a similar result at Berne.

M. Freuderich reports also other similar results from different localities, and observes that the purity of the air of the mountains is far greater than had been deduced from the trials of Pasteur and others; that it is not exceeded by the air over the ocean, from which Commander Moreau obtained (according to a communication from Dr. Miquel in the Semaine Medicale of March 6, 1884), five to six Bacteria to a cubic meter.

3. *Description of an impregnated uterus and the uterine ova of Echidna hystrix.*—Professor Richard Owen (Ann. Mag. N. H., V, xiv, 373, Dec., 1884), refers to his papers in the Philosophical Transactions of 1865 and 1880, on reproduction in the Echidna, and his account and figures in the latter paper illustrating a specimen in which the left uterus contained three ova, the largest 6^{mm} in diameter. He then gives a description and figures

of the right and left uterus, each with a collapsed ovum, of an Echidna captured near Toowoomba, in 1882. In both uteri the absence of any connection of the ova with the uterine walls was shown by their floating freely as moved by the feeble wave of the menstruum in which the dissection was made.

The paper closes with a copy of a letter from W. H. CALDWELL addressed by him to the Sydney (N. S. W.) Herald, Sept. 16, 1884. Mr. Caldwell observes that in both the Ornithorhynchus and Echidna "the amount of food-yolk in the egg is very large, and that consequently, there is only a partial *segmentum* (meroblastic type)." The egg is laid at an age equal to a 30-hour-old chick, and is enclosed in a strong, flexible, white shell; it is three-quarters of an inch long in the longer diameter, and one-half inch in the shorter. Ornithorhynchus produces two eggs at a birth, Echidna, one; the former places the eggs at the end of one of the burrows, the latter her one in a ventral pouch. Mr. Caldwell states that he has already worked out most of the stages in the development, and hopes to obtain a sufficient number of specimens to complete his investigation during the present breeding season. He has also obtained, since his arrival last October, many embryos of several genera of Marsupials for study.

4. *A Polythalamian from a Salt-pool near Déva in Transylvania.*—The first known species of a polythalamian from continental waters has been described by Dr. E. VON DADAY. Its shell is much like that of a *Rotalia* in its spiral form; like *Trochammina* in structure; and like the *Difflugiæ* and the *Polymorphina silicea* in the constitution of its shell, it being chitinous with some siliceous scales in its texture. The author names it *Entzia tetrastomella*, and regards it as probably representing a group, along with some forms of the genus *Trochammina*, which unites the imperforate with the perforate Polythalamia, and the group of the Lagenidæ with that of the Globigerinæ. Of the associated protozoans in the salt-pools in the region, nine have hitherto been found only in saline inland waters, while ten occur both in saline inland waters and the sea, and seven of these ten are found both in fresh and saline inland waters. Dr. Daday remarks that the facts decidedly favor the opinion of Professor G. Entz, that the protozoans of the saline inland waters of Transylvania are more nearly allied to those of the sea than to those of the fresh water.—*Ann. Mag. N. Hist.*, Nov., 1884.

5. *Food of Mice.*—Professor F. H. STORER, in a paper in the Bulletin of the Bussey Institution, (vol. ii, Part iv, 1884), describes the effects of feeding mice on painter's putty (made of ground chalk (whiting) and oil, either linseed or fish oil), and putty made of other substances. They were fed with the whiting putty in balls and ate freely 10 or 12 balls (12 weighing 20 grams, of which 3·3 grams were oil) daily besides their allowance of oats. The excrements became white and chalky, free from the oil and very abundant, the quantity of chalk discharged amounting to more than one-third the weight of the animals.

A like mixture of barium carbonate or lead carbonate and oil, killed the mice; but they ate, apparently without injury, a putty made of mixed barium carbonate and whiting, in the proportion of 1 to 5, and so also a putty made of lead carbonate and whiting, in the proportion of 1 to 4. The protective influence of the calcium carbonate in these cases is, as Dr. Storer observes, a fact of much interest; and the fact that they eat common putty with relish for the oil it contains is one of public importance.

6. *Annals of the New York Academy of Sciences.*—Numbers 3 and 4 (in one) of the Annals contains an elaborate paper by W. G. BINNEY on the Jaw and Lingual Dentition of Pulmonate Mollusks, illustrated by 16 plates.

7. *Prodromus Faunæ Mediterraneæ, sive Descriptio Animalium Maris Mediterranei Incolarum*, quam comparata Silva rerum quatenus innotuit adjectis locis et nominibus vulgaribus, eorumque auctoribus in commodum Zoologorum congessit Julius Victor Carus. Pars. I, Cœlenterata, Echinodermata, Vermes. 283 pp. 8vo. Stuttgart, 1884. (E. Schweizerbart'sche Verlagsh. (E. Koch)).—This first part of the Prodromus contains brief classified descriptions of the animal species of the Mediterranean, belonging to the tribes stated in the title, and has been prepared by one of the best of European zoologists. It is especially convenient for the zoological laboratories on the coasts of the Mediterranean, but has great value for other seas and regions.

8. *The Auk: a Quarterly Journal of Ornithology.*—No. 4 of the first volume of this excellent journal was issued in October. Mr. E. P. Bicknell publishes in it an interesting "Study of the Singing of our Birds;" J. P. Howley a paper on the Canada Goose (*Bernicla Canadensis*); W. W. Cooke, on the distribution and migration of Harris's Finch (*Zonotrichia querula*); F. Stephens, on LeConte's Thrasher, and collecting in the Colorado Desert; J. A. Allen, on zoölogical nomenclature; besides which there are various other valuable contributions.

9. *The Siluroid fish, Amiurus catus.* — A thorough study of this species has been made by Canadian zoologists and the results are the subjects of several finely illustrated articles in the Proceedings of the Canadian Institute, Toronto, vol. ii, fasc. 3, Oct., 1884; by Professors R. RAMSAY WRIGHT, J. PLAYFAIR MCMURRICH, A. B. MACALLUM, and T. MCKENZIE.

10. *The Development of Renilla;* by EDMUND B. WILSON, Ph.D., Fellow of the Johns Hopkins University. 93 pp., 4to, with 16 plates.

IV. ASTRONOMY.

1. *Abstract of a Report to the Solar Physics Committee on a Comparison between apparent Inequalities of Short Period in Sun-Spot Areas and in Diurnal Temperature-Ranges at Toronto and at Kew;* by BALFOUR STEWART, M.A., LL.D., F.R.S., and WILLIAM LANT CARPENTER, B.A., B.Sc.—It has been known for some time that there is a close connection between the inequalities

in the state of the sun's surface as denoted by sun-spot areas and those in terrestrial magnetism as denoted by the diurnal ranges of oscillation of the declination magnet; and moreover the observations of various meteorologists have induced us to suspect that there may likewise be a connection between solar Inequalities and those in terrestrial meteorology.

This latter connection, however (assuming it to exist), is not so well established as the former, at least if we compare together Inequalities of long period. It has been attempted to explain this by imagining that for long periods the state of the atmosphere as regards absorption may change in such a manner as to cloak or diminish the effects of solar variation by increasing absorption when the sun is strongest and diminishing absorption when the sun is weakest.

On this account it seemed desirable to the authors to make a comparison of this kind between short-period Inequalities, since for these the length of period could not so easily be deemed sufficient to produce a great alteration of the above nature in the state of the atmosphere.

The meteorological element selected for comparison with sun-spots was the diurnal range of atmospheric temperature, an element which presents in its variations a very strong analogy to diurnal declination-ranges.

There are two ways in which a comparison may be made between solar and terrestrial Inequalities. We may take each individual oscillation in sun-spot areas, and find the value of the terrestrial element corresponding in time to the maximum and the minimum of the solar wave. If we were to perform this operation for every individual solar Inequality, and add together the results, we might probably find that the magnetic declination-range was largest when there were most sun-spots. If, however, we were to make a similar comparison between sun-spot daily areas and diurnal temperature-ranges we might not obtain a decisive result. For at certain stations, such as Toronto, it is suspected (the verification or disproval of this suspicion being one of the objects of this paper) that there are two maxima and two minima of temperature-range for one of sun-spots. The effect of this might be that in such a comparison the temperature-range corresponding to a maximum of sun-spots might be equal in value to that corresponding to a minimum, or, in other words, we should get no apparent result, while, however, by some other process proofs of a real connection might be obtained. But if we can get evidences of apparent periodicity in sun-spot fluctuations when dealt with in a particular manner, we have at once a method which will afford us a definite means of comparison. And here, as Professor Stokes has pointed out, it is not necessary for our present purpose to discuss the question whether these sun-spot Inequalities have a *real* or only an *apparent* periodicity. All that is needful is to treat the terrestrial phenomena in a similar manner, or in a manner as nearly similar as the observations will allow,

and then see whether they also exhibit periodicities (apparent or real) having virtually the same times as those of sun-spots, the phases of the two sets of phenomena being likewise allied to one another in a constant manner.

It is such a comparison that the authors have made, their method of analysis being one which enables them to detect the existence of unknown Inequalities having apparent periodicity in a mass of observations. A description of this method has already been published in the "Proceedings of the Royal Society" for May 15th, 1879. The comparison was made by this method between sun-spot observations extending from 1832 to 1867 inclusive, Toronto temperature-range observations extending from 1844 to 1879 inclusive, and Kew temperature-range observations extending from 1856 to 1879 inclusive. The following conclusions were obtained from this comparison.

(1) Sun-spot Inequalities around 24 and 26 days, whether apparent or real, seem to have periods very nearly the same as those of terrestrial meteorogical Inequalities as exhibited by the daily temperature-ranges at Toronto and at Kew.

(2) While the sun-spots and the Kew temperature-range Inequalities present evidence of a single oscillation, the corresponding Toronto temperature-range Inequalities present evidence of a double oscillation.

(3) Setting the celestial and terrestrial members of each individual Inequality, so as to start together from the same absolute time, it is found that the solar maximum occurs about 8 or 9 days after one of the Toronto maxima, and the Kew temperature-range maximum about 7 days after the same Toronto maximum.

(4) The proportional oscillation exhibited by the temperature-range Inequalities is much less than the proportional oscillation exhibited by the corresponding solar Inequalities.—*Proc. Roy. Soc.*, No. 232.

2. *Astronomical Observations and Researches made at Dunsink.* Fifth Part, Dublin, 1884.—Dr. Ball has in this volume given the result of a systematic search for stars of measurable parallax. Nearly four hundred stars were examined, with a negative result; that is, they did not indicate an annual parallax large enough to lead him to give further attention to them. The details of his measurements are given. Upon four stars, however, Dr. Ball has made elaborate measurements and obtained these parallaxes:

61 Cygni,	$\pi = 0''{\cdot}4676$.
Groombridge, 1618,	$\pi = 0''{\cdot}322$.
P. III, 242,	$\pi = 0''{\cdot}045$.
6 Cygni,	$\pi = 0''{\cdot}482$.

The parallax of 61 Cygni differs little from that obtained by Professor Hall at Washington, Professor Hall's result being $0''{\cdot}4783$. The several parallaxes of this double star obtained by Struve, Auwers, Hall and Ball indicate that the true value cannot differ much from one-half a second. The small negative parallax

of P. III, 242, strictly taken implies that this star is a little more distant than the 8th magnitude comparison star, 37°, 877.

3. *Zones and Zone Catalogue of the National Argentine Observatory.*—The four quarto volumes of star positions referred to by Dr. B. A. Gould in his letter in the December number of this Journal, have been received. Two of them, vols. iii and iv, contain zone observations made in 1873, and two, vols. vii and viii, contain the zone catalogue. This extends from declination $-23°$ to $-80°$, covering thus a zone from $-23°$ to $-30°$ which Argelander had observed near his southern horizon at Bonn, and part of the region of Gilliss's observations near the South Pole.

The whole number of stars in the Catalogue is 73,160. A few stars are entered as of the tenth magnitude, though the limit was in general the $9\frac{1}{2}$ magnitude. Most of the stars were observed but once, the total number of zone observations being somewhat over 100,000. This zone catalogue constitutes the second of the three principal contributions which the Argentine Government and Dr. Gould are furnishing to astronomers. The first was the Uranometria Argentina, already published; the third is the general catalogue of stars spoken of in his letter to Professor Dana, quoted in the last number of this Journal.

4. *International Conference held at Washington for the purpose of fixing a Prime Meridian and a Universal Day, October,* 1884.—A volume of 212 pp., large octavo, has just been published containing detailed reports of the eight sessions of the International Conference, the first held on October 1st, and the last on November 1, 1884. This record is all the more valuable and interesting in view of the important results to which the discussions here printed in full finally led.

V. Miscellaneous Scientific Intelligence.

1. *Systematic Earthquake Observations.*—On Nov. 21, 1884, a conference was held in Washington to consider and arrange a systematic plan of earthquake observation throughout the country. It was called by the Director of the Geological Survey, and there were present Messrs. J. W. Powell, C. E. Dutton, and G. K. Gilbert of the Geological Survey, H. M. Paul of the Naval Observatory, Cleveland Abbé and C. F. Marvin, of the Signal service, W. M. Davis of Harvard College and C. G. Rockwood, Jr., of Princeton College.

It was considered desirable to attempt work in two directions. First.—The collection of more reliable non-instrumental observations, by the general distribution of circulars of information and blank reports, to be filled up and returned to some central office after the occurrence of an earthquake. It is proposed to distribute these circulars as widely as possible, and Professor Rockwood was requested to prepare forms for the necessary correspondence. Second.—The establishment of stations provided with instruments for the more or less complete recording of the earth's mo-

tion. These would probably be of two grades; the more numerous ones having some simple and inexpensive form of seismoscope to record the occurrence of a shock and to mark the time as exactly as possible, while a less number of selected stations would be provided with more elaborate seismographs to record as fully as possible the details of the earth's movement. As preliminary work in this direction, Messrs. Paul, Rockwood and Marvin are to report upon the form of instruments to be adopted; and Messrs. Rockwood, Abbé and Davis are to consider the best geographical distribution of the stations; Professor Rockwood having undertaken to prepare a chart of the geographical distribution of the earthquakes which have occurred in the United States and Canada in the last twelve years as recorded in his published lists.

Besides this preparation for observational work Mr. Davis is to report upon the bibliography of recent seismology, and Mr. Paul upon instruments already employed in other countries, especially Japan; while other related topics are not overlooked. The work is to be conducted under the supervision of the U. S. Geological Survey which will attend to the executive details of the scheme. And when sufficient observations have been collected they will be put into the proper hands for Scientific discussion. C. G. R.

2. *Volcanic Phenomena of* 1883. (Die Vulcanische Ereignisse des Jahres 1883. 19. Jahresbericht von C. W. C. Fuchs.—Min. u. Petrog. Mittheil.)—The report of C. W. C. Fuchs contains as usual an account of the volcanic eruptions and earthquakes of the year. Moderate eruptions of Etna are noted during March and April, and others during the year from Vesuvius and Cotopaxi and also in Iceland, Nicaragua, Colombia and Alaska. But by far the most important outbreak was the great eruption of Krakatoa, in the straits of Sunda, on August 26 and 27.

The activity of this volcano, which formed a small uninhabited island lying between Java and Sumatra, was first reported by a passing vessel on May 20, as indicated by white clouds topping its peak and a considerable fall of ashes. It was noted from time to time during the summer by subterranean explosions, by the expulsion of ashes and by the presence of large amounts of pumice in the neighboring seas. The great eruption began on August 26 and culminated on the 27th in a grand explosion, by which a large portion of the mountain was blown bodily into the air and fell in the neighboring straits, forming there two new islands of considerable size, which however have since yielded to the eroding action of the waves. At the same time destructive eruptions of lava and ashes were taking place from the volcanoes Maha Meru, Gunung Gunter, Kandang and Papandayang in Java.

The explosion of Krakatoa not only changed very much the conformation of that island, reducing its land area by over two-thirds, but gave rise to immense sea waves, which washed all the surrounding coasts, carrying death and destruction to all in their way, and were still sensibly felt at far distant places in Africa and America. It also caused an atmospheric wave which was

traced three times around the earth by irregularities in the tracings of self-registering barometers.

Dr. Fuchs does not favor the idea that the wonderful sky-glows observed during the past winter were caused by dust from Krakatoa disseminated in the upper strata of the atmosphere. And he remarks that "the eruption of Krakatoa although very violent has been equaled or exceeded by others; e. g., that of Asamayama 1783, of Temboro 1815, of Coseguina 1835, as well as by Hekla 1845, Mauna Loa 1866, and Pochutla 1870. In no one of these cases," he says, "was a similar sky-glow observed." It may be remarked, however, that the absence of any such observation in connection with former great eruptions is by no means conclusive; for some eruptions, as that of Mauna Loa referred to, consisted mostly of lava flows, with which no great amount of ashes was ejected, nor to any great altitude;—others, as Hekla, which exhibited more of the explosive character, were in much higher latitudes and out of the great equatorial currents of the atmosphere; while in earlier cases, as Temboro, the phenomena might easily have escaped recognition and record.

The record of earthquakes includes 263 items, of which 79 are on the American Continent and have been already noticed in this Journal.* By seasons they are distributed as follows:—Winter 56 (Dec. 21, Jan. 21, Feb. 14); Spring 66 (March 22, April 20, May 24); Summer 68 (June 20, July 29, Aug. 19); Autumn 73 (Sept. 29, Oct. 30, Nov. 14). On 41 days there were shocks in two or more localities, and at 24 places there were shocks on several dates.

The most important earthquake was that in Ischia, July 28.† In regard to its causes Dr. Fuchs says:—The earthquake of July, 1883, does not belong to the volcanic earthquakes hitherto frequent in the island; and a real downfall or a collapse of a great cavity finds as little reason. The materials of the hill have only shifted somewhat and rearranged themselves until they again found sufficient support. And this change was completed at a moderate depth. On this account was the surface action of the earthquake uncommonly strong and its extent very limited."

An appendix adds a few items for 1880 and 1882, and notices the monograph of Professor A. Forster on the Berne Earthquake of Jan. 27, 1881; and that of Dr. R. Canaval on the Carinthian Earthquake of Nov. 5, 1881. C. G. R.

3. *Second Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution*, 1880–81; by J. W. POWELL, Director. 477 pp. 4to, with numerous plates and figures. Washington, 1884.—This volume is a worthy companion in its subject matter and illustrations to its predecessor issued a year or so ago. It shows the rapid progress which is being made in the work of studying and recording the languages, manners and customs of our Indian tribes—a work the value and importance of which can hardly be overestimated. The volume

* vol. xxvii, p. 358. † vol. xxvi, p. 473.

opens with the report of the Director, in which is given a statement of the plan on which the work is being carried forward, and a summary of the work done by a number of specialists in different subjects. The following is a list of the papers printed in full and making up the bulk of the volume: Zuñi fetiches, by F. H. Cushing; Myths of the Iroquois, by Mrs. Erminnie A. Smith; Animal Carvings from the mounds of the Mississippi Valley, by H. W. Henshaw; Navajo Silversmiths, by Dr. Washington Matthews, U. S. A.; Art in Shell of the ancient Americans, by W. H. Holmes; Illustrated Catalogue of the collections obtained from the Indians of New Mexico and Arizona, in 1879, and from the Indians of New Mexico, in 1880, by James Stevenson. These papers contain a vast amount of interesting and valuable material rendered the more attractive by the profusion of illustrations, upwards of 700 in number, and many of them colored, the excellence of the execution of which leaves nothing to be desired.

4. *Bulletin of the New England Meteorological Society*, No. 1, November, 1884, with a map.—This bulletin contains a summary of the meteorological conditions of New England for November, based upon reports from forty-five observers, six of whom were connected with the U. S. Signal Service. Besides the statement of the conditions as to precipitation, temperature, storms, wind, auroras and earthquakes, etc., some experiments are mentioned as having been made by Mr. Desmond Fitz Gerald, of Brookline, "to show the highest and lowest temperatures in the open air and in the woods under deciduous, and under pine trees. Extreme differences of 7° in the maximum, and 9° in the minimum temperatures were noted. The mean of twenty-four observations gave the following results:

	Open Air.	Deciduous Woods.	Pine Woods.
Maximum	50°·82	50°·18	47°·88
Minimum	25°·82	26°·32	25°·58"

In regard to the objects aimed at by the Society we quote from the Bulletin. "The New England Meteorological Society was formed in Boston, in June, 1884, to promote the study of atmospheric phenomena in New England. The aim of the Society is to promote uniformity and accuracy among observers, to establish systematic observations in new localities, and to discuss and publish the results obtained. . . . The Council has begun its work by undertaking to collect statistics of meteorological phenomena, and to issue a monthly bulletin containing a summary of the observations, with such other items of interest as it may be possible to present from time to time. Special attention is paid to precipitation and range of temperature, and many more observers are needed. Observations are welcomed from any one, whether a member of the Society or not. In order to secure greater uniformity and accuracy in the records, circulars have been prepared containing suggestions as to instruments to be used and the best methods of exposure; they can be obtained on application to the Director, together with blank forms for record-

ing the observations. The Society is a voluntary association, and depends upon the fees of its members for the cost of issuing its bulletin, and for its other expenses. It is, therefore, hoped that all interested in meteorology will connect themselves with it and aid in promoting the objects it has in view. Correspondence relating to the Society and to membership should be addressed to W. M. Davis, Secretary, Cambridge, Mass. Correspondence relating to matters of observation should be addressed to Winslow Upton, Director, Providence, R. I."

5. *American Society for Psychical Research.* — A Society has been recently organized at Boston, the object of which, like that of a similar Society formed in England in 1882, is (to quote from the proceedings of the latter) to make "an organized and systematic attempt to investigate that large group of debatable phenomena designated by such terms as mesmeric, psychical and spiritualistic. From the recorded testimony of many competent witnesses, past and present, including observations recently made by scientific men of eminence in various countries, there appears to be, amidst much illusion and deception, an important body of remarkable phenomena, which are *primâ facie* inexplicable on any generally recognized hypothesis, and which, if incontestably established, would be of the highest possible value. The task of examining such residual phenomena has often been undertaken by individual effort, but never hitherto by a scientific society organized on a sufficiently broad basis. The aim of the Society is to approach these various problems without prejudice or prepossession of any kind, and in the same spirit of exact and unimpassioned inquiry which has enabled science to solve so many problems, once not less obscure nor less hotly debated."

The Committee appointed consists of nine gentlemen, viz: G. Stanley Hall (Chairman), E. C. Pickering, William James, Alpheus Hyatt, Samuel H. Scudder, H. P. Bowditch, C. S. Minot, William Watson, N. D. C. Hodges (Secretary, 19 Brattle street, Cambridge).

6. *American Pearls.* — At the Philadelphia meeting of the American Association for the Advancement of Science, Mr. Geo. F. Kunz read a preliminary paper on the "American Pearl," treating of its history, production, value and uses. Mr. Kunz states that he is still engaged on this subject, which will in the near future be illustrated and published by the United States Fisheries Commission in their bulletin, and he would greatly appreciate, and give full credit for, any reliable facts that may be furnished to him. His address is Tiffany & Co., New York City.

7. *Spaziergänge durch das Reich der Sterne;* Astronomische Feuilletons von M. Wilhelm Meyer. 321 pp. 8vo. Vienna, 1885 (A. Hartleben's Verlag).—The author, formerly first astronomer in Geneva, has brought together in this volume a very readable and, for the general public, instructive series of essays upon various astronomical subjects. They are written in a bright fresh style with a good deal of quiet humor. A fair impression

of the character of the volume may be obtained from the titles of some of the chapters taken at random, such as:—The Son of the Earth (the Moon); A well known guest (the Comet Pons); The Star of the three Kings (new Stars); How one becomes an Astronomer (Bessel).

8. *Elisha Mitchell Scientific Society of Raleigh, N. C., Journal for the year* 1883–84.—This society, now a year old, is named after an able professor of Chemistry of the University of North Carolina, Elisha Mitchell—"a naturalist by inheritance, by inclination, by education and by profession"—whose lamented death occurred in 1857, by a fall from a precipice while descending Black Mountain. In 1835 he measured the altitude of this peak, and found it 5,508 feet above Morgantown, which, with the now known height of Morgantown, makes it 6,708 feet above the sea—only 7 feet above the height obtained by Professor Guyot in 1856. His ascent in 1857 was undertaken to remove a lingering doubt as to whether the peak measured was the highest or not of the group. The name given the society is one of many honors to his memory from the citizens of North Carolina. This first publication of the Society contains papers on the phosphatic deposits of North Carolina, by C. W. Dabney, Jr. and W. B. Phillips, analyses of the cassiterite of King's Mountain, N. C., by C. W. Dabney; on Indian Burial Grounds of North Carolina, by J. A. Holmes, and other papers of interest.

9. *Leisure Hours among the Gems;* by AUGUSTUS C. HAMLIN. 439 pp. 8vo, with two colored plates. Boston, 1884 (James Osgood & Co.)—The author has brought together in this volume many interesting facts in regard to the more important gems, their occurrence, history, etc. The scientific theories advanced, however, will not always bear examination, and a good deal of space is given to the discussion of irrelevant matter.

A Treatise on the Principles of Chemistry, by M. M. Pattison Muir, M.A., F.R.S.E. 488 pp. 8vo. Cambridge, 1884. (University Press.)

The Elements of Chemistry, Inorganic and Organic, by Professor Sidney A. Norton. 504 pp. 8vo. Cincinnati and New York, 1884. (Van Antwerp Bragg & Co.)

Bulletin de la Société Belge d'Électriciens, Tome premier, 1884. Brussells.

Bulletin No. 2, of the Illinois State Museum of Natural History, Springfield, Illinois, 28 pp. 8vo. Contains descriptions of new Carboniferous Crustaceans, Mollusks and Crinoids, by A. H. Worthen.

Memoirs of the Geological Survey of India.—Fossil Echinoidea from Western Sind, with 16 plates, by P. Martin Duncan and W. Percy Sladen. Calcutta, 1882

OBITUARY.

HERMANN KOLBE.—It is announced that the German chemist, Professor Hermann Kolbe, died suddenly on the 25th of last November, in his 67th year. A sketch of his life and work is promised to appear in the coming number of the *Journal für praktische Chemie*, of which he was long the editor.